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MOBILE HANDBOOK

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Mobile Handbook

by

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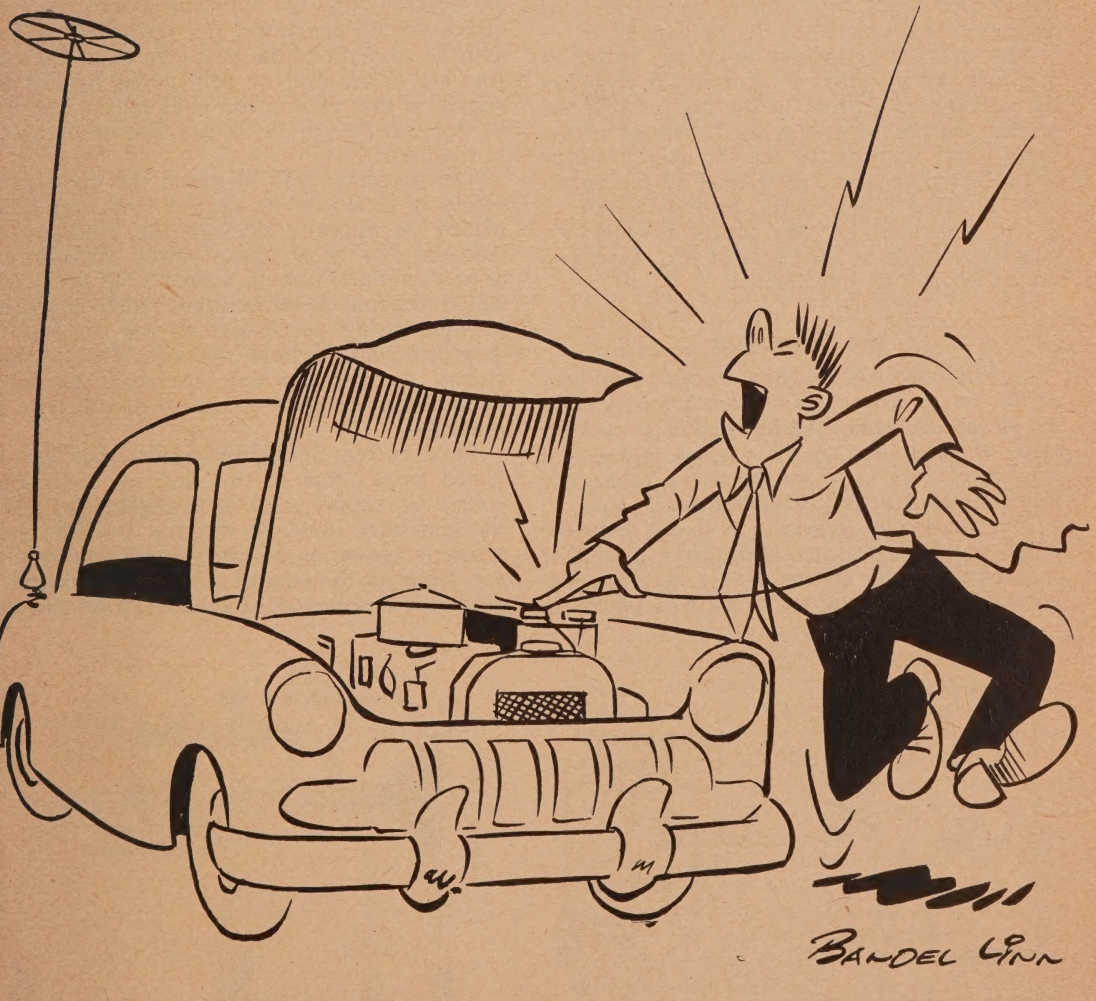
Automotive Ignition System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Automotive Ignition System

The purpose of the battery-type ignition system is to furnish a spark to ignite the gas-air mixture in the cylinders of the automobile engine. A voltage of above 6000 volts is required for this purpose. *Figure 1* illustrates the components and hookup of a typical system using an ignition coil and a distributor.

When the ignition switch is closed, the closing and opening of the engine-driven breaker points controls the flow of current into the primary winding of the ignition coil. This interrupted current creates and collapses a magnetic field in the coil. This field induces a secondary voltage which is stepped up to the required level and distributed to the correct spark plug at the right time by the distributor. The distributor and breaker are driven by the engine thru a gear arrangement, and their speed of operation is controlled by the engine.

The breaker condenser is of the order of 0.25 ufd. Its purpose is two-fold: It regulates the collapse of current in the coil so that the proper amount of energy is developed in the spark, and it protects the breaker contacts from the oxidizing arc developed during operation. A damped oscillatory wave of about 12 kc. is generated by this action (*Figure 2*). Chapter 4 explains the effect of this wave as a source of ignition interference.

The Generator

As the source of charging energy is the generator, let us first examine this component of the electrical system. While the precise connections of generators in the various makes and models of cars vary one from the other, the following explanation is fundamentally true.

The automobile generator is based upon the principle whereby a current flow in a conductor is induced by the influence of a moving magnetic field. The conductor is the wire placed in a slot in the armature (rotor) of the generator. The magnetic field is created by the field coils and poles. Motion is introduced by the rotation of the armature. Thus the conductor is moved with respect to the stationary magnetic field.

A conductor moving in a circular path will move past one field pole, then the other, but in the opposite direction. As a result of this apparent reversal of direction, the induced current in the conductor also reverses. Since a direct current is needed to charge the battery, the reversible current (alternating current) must be changed to d.c. In the automobile generator this rectification is accomplished by the *commutator*. Here, collector brushes are located in such a position as to connect each conductor in turn, one after the other, to the external circuit at just the right time to rectify the generated a.c. wave. In this manner a direct current output is obtained from the generator.

The maximum output voltage and current are controlled by the mechanical and electrical design of the generator, the speed of rotation and the strength of the magnetic field. Generators are either gear or belt driven by the car engine so that their speed is directly controlled by the car speed; no other control of speed is required.

The magnetic field in which the conductors rotate is produced by special soft iron poles placed on opposite sides of the armature so that the flux they create passes through the armature. Each pole is wound with field coils which become electromagnets, their magnetic strength being controlled by the amount of current flowing through the coils. This current, known as *field current,* becomes the main method by which the generator output may be regulated.

Field current in any generator may be obtained from either of two sources: a separate source of supply such as a battery, or from the generator itself. In the first case the generator is known as a *separately-excited* generator, while in the second case it is known as a *self-excited* generator. *Figure 3* shows the cir-

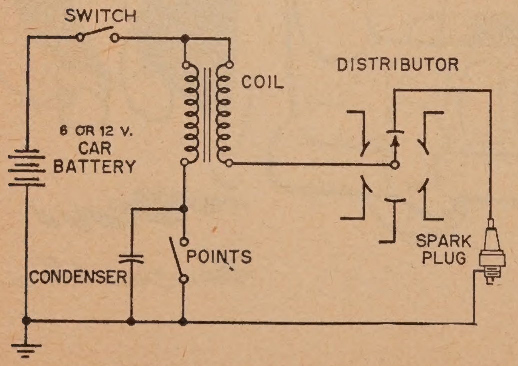


Fig. 1. A typical six cylinder ignition system.

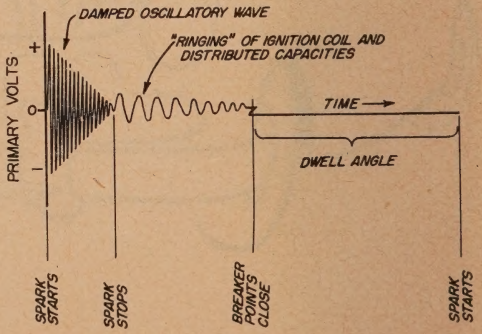


Fig. 2. The primary voltage wave as viewed on an oscilloscope.

cuit of a separately-excited generator, and *Figure 4* shows the circuit of a self-excited unit.

As shown in *Figure 5* the output of any generator may be controlled by field current. From this figure it can be seen that a much larger value of output current would result from a high field current. The absolute maximum capacity of a generator is limited by its design and the maximum strength of magnetic field that can be obtained. In practice, the maximum output is limited by the safe temperature at which the unit can be operated, since high output current means high armature and field currents, and high I^2R heat losses.

Since a self-excited generator supplies its own field current, it is obvious that with no output there is no field current, and with no field current there is no apparent output. This poses the problem of starting the generator to operate in the first place. The incongruity here posed has been resolved by the designers of the generator by the simple expedient of the use of proper materials. The metal selected for use in the field pole pieces is of such a nature as to retain a slight amount of magnetism even though the field current has fallen to zero. In this manner some output is produced even for zero field current, producing a condition wherein the generator will build up to normal output levels without special attention.

The usual rating of a car generator is of the order of 30 to 50 amperes. If the generator is not properly controlled, or regulated, it can cause extensive damage to the automobile electrical system and the battery. The generator can also be burned out by lack of proper control.

Ignition System Regulators

A shunt-wound generator, which is the type usually found in automobiles, has voltage and current characteristics that vary greatly with

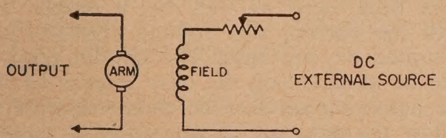


Fig. 3. Schematic of a separately-excited shunt generator.

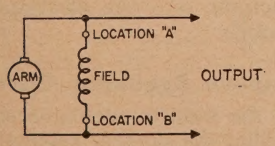


Fig. 4. Schematic of a self-excited shunt generator.

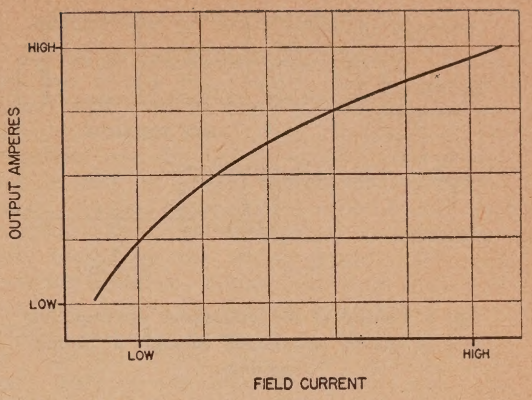


Fig. 5. The output of a self-excited shunt generator is directly proportional to the field current. The maximum output is limited by the design of the generator.

changes in generator speed and load (*Figure 5*). *Voltage regulation* limits the maximum generated voltage to a preset value to prevent burned out lights and damage to the ignition system and electrical accessories. *Current regulation* limits the maximum output current of the generator and protects the generator against excessive loads. A *cutout relay* is used as a reverse current switch for disconnecting the generator from the battery when the generator output voltage is less than the battery voltage. This will prevent the generator from acting as a direct short across the battery, or in some cases behaving like a d-c- motor.

Figure 6 shows a typical "three unit" voltage regulator incorporating these three above-mentioned devices. Let us examine each one in turn:

The Voltage Regulator

A two-brush shunt-wound generator is shown in *Figure 7*. The voltage produced by this generator is a function of the speed of armature rotation and of the strength of the magnetic field. Since the speed of rotation depends upon the speed of the car motor, voltage regulation must be accomplished by controlling the strength of the magnetic field. Since the strength of this field is proportional to the amount of current flowing through the field winding, it is practical to control the output voltage of the generator by changing the resistance of the field circuit. This can be done by a field potentiometer, as was done in many of the older cars (*Figure 8*). In order to obtain automatic regulation a device is needed which will maintain a constant generator voltage regardless of car speed. A vibrator type regulator is commonly used for this purpose. It does the job by automatically inserting and removing the field resistance at very small voltage differentials (*Figure 9*). The contacts in such a voltage regulator may operate 200 times a second or more, inserting and removing field resistance. The contacts are actuated by a

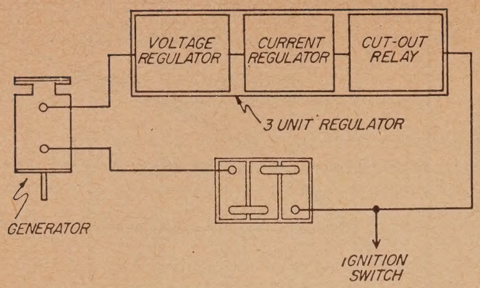


Fig. 6. Control of the automotive electrical system is usually maintained through a "3-unit" regulator.

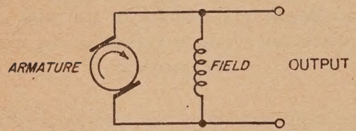


Fig. 7. The most common automobile generator is a shunt-wound model with the field connected across the output.

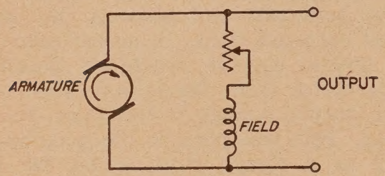


Fig. 8. Voltage output from a shunt-wound generator may be controlled by a variable resistance in series with the field winding.

voltage sensitive coil placed across the output of the generator. Some regulators also have a current coil, sensitive to changes in field current. When the output voltage rises above a certain amount the coil actuates the regulator contacts which open, placing the series resistor, *R*, in the field circuit. This drops the voltage output of the generator. By proper adjustment of the spring of the voltage regulator, the cutout voltage setting of the regulator may be accurately set.

The actual field current flowing during regulator operation is shown in *Figure 10.* It can be seen that the average value of field current could be regulated by changing the spring tension on the regulator arm. This will change the rate of opening and closing of the resistor shunting circuit.

The Current Regulator

Current regulation of a two-brush shunt-generator is accomplished in much the same manner as is voltage regulation. *Figure 11* shows a typical current regulator. A resistance, *R*, is placed in series with the field winding, and is intermittently inserted and removed from the circuit by a vibrating regulator. The current regulator coil, however, is inserted in series with the generator load and is sensitive to load currents, rather than to generator voltage, as was the coil of the voltage regulator. This current regulator coil is composed of a few turns of heavy wire, and carries the full generator output current. When the load current is heavy enough, the magnetic pull of the coil will overcome the spring tension and the regulator contacts will open, inserting a regulating resistor into the field circuit of the generator. This will drop the generator output current. The current reduction decreases the magnetic pull of the coil and the relay spring closes the contacts. This action may take place from two to fifty times a second. The result is fairly smooth current regulation.

The Cutout Relay

The purpose of the cutout relay is to connect the generator to the battery when the generator voltage is greater than the voltage of the battery, and to disconnect the generator from the battery when the generator voltage is less than the voltage of the battery. *Figure 12* shows the schematic of a cutout relay. A spring holds the relay contacts normally open. The coils *S* and *V* actuate the relay to open and close the contacts. Coil *V* is a voltage coil composed of many turns of wire. It is adjusted to close the contacts when the generator voltage is slightly higher than the battery voltage. The generator current, flowing through coil *S*, made of a few turns of heavy wire, adds the pull of this coil to the pull of coil *V*. As the generator voltage falls below the battery voltage, the current flowing through coil *S* reverses its direction and coil *S* bucks coil *V* and reduces the total coil pull enough so that the spring force is sufficient to open the contacts, disconnecting the generator from the battery.

A Combined Voltage and Current Regulator Unit

The two brush generator requires both voltage and current regulation, as described above. This dual need is met by a single device with the current and voltage regulator relays mounted on one base. The cut-out relay may also be mounted on the base. *Figure 13* shows the active circuit for the three relay unit. To follow the sequence of operation, it should be kept in mind that the voltage and current regulators never operate at the same instant. *Figure 14* shows a typical regulator layout and connections into the electrical system of the automobile.

Complete Regulator Operation

Assume the voltage regulator is set for 7.3 volts, and that the current regulator is set for 20 amperes. The operation will follow this sequence:

2. The engine speed is increased, the generator voltage increasing simultaneously.
3. When the generator voltage reaches 6.3 volts, the cutout contacts, *Co*, close, allowing the current from the generator to charge the battery.
4. When the generator voltage reaches 7.3 volts, the voltage regulator contacts, *Vr*, operate and maintain generator voltage at 7.3 volts, plus or minus 0.15 volts, regardless of the car speed or generator load.
5. If the generator load current exceeds 20 amperes because of a low battery or excessive load from headlights or electrical accessories, the current regulator contacts, *Cr*, operate and limit the generator current to 20 amperes regardless of generator speed. The remainder of the load current is supplied by the car battery.
6. When the engine speed falls below about 8 miles per hour the cutout contacts open and disconnect the battery from the generator.

Regulator Adjustment

The addition of radio equipment to an automobile means that the electrical system of the car will be called upon to deliver some 15 to 50 amperes during transmission periods, and perhaps 10 amperes during receiving periods. This assumes that indirectly heated tubes are used and that the car broadcast receiver is used in conjunction with a converter. The regulation devices in the car are usually not adjusted to take this magnitude of load and continued use of the mobile equipment may soon result in a discharged storage battery. However, by properly adjusting the current and voltage regulators in the automobile a power load of this order can be safely handled with no danger to either the automobile battery or the charging equipment.

Adjustment of the Cutout Relay

Proper adjustment of the cutout relay may be made by measuring the voltage between the "GEN" terminal of the regulator and ground with the engine idling. This voltage will be anything between zero to about five volts. *Slowly* increase engine speed, noting the voltage at which the cutout relay closes. This should be in the range of 6.0 to 6.5 volts. Adjust the spring tension of the cutout relay (if necessary) to obtain this reading. Increasing spring tension raises the reading, decreased tension lowers it.

Adjustment of the Current Regulator

Proper setting of this relay, usually the center one of the three relays and wound with heavy wire, can be done by inserting an ammeter between the "GEN" terminal of the regulator and the "A" terminal of the generator. Adjust the spring tension of the current relay to cause the relay to open at the rated current output (see nameplate) of the generator. Increasing the spring tension raises the opening current. Some regulators have adjustment screws for tension adjustment, others require bending of the tab to which the spring is fastened. Bend this very carefully and very little at one time. When you have this adjustment correct, the generator will charge to its maximum capacity without exceeding its safe operating limits. During the above

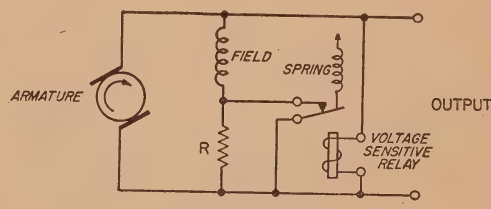


Fig. 9. The usual automotive practice is to control the voltage output by inserting a fixed resistance in series with the field. The insertion or removal of the resistance is performed automatically by a voltage sensitive relay connected across the generator output.

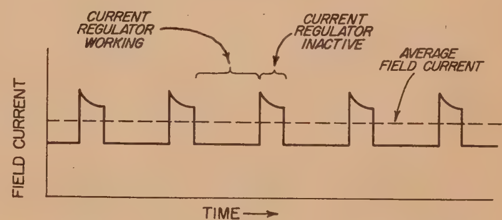


Fig. 10. Oscilloscope pattern of the field current of a generator with the current regulator in operation. The rate of change may vary between 30 and 200 times per second.

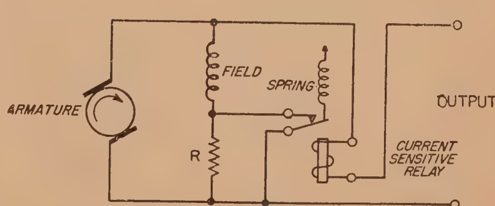


Fig. 11. The current regulator circuit is essentially the same as the voltage regulator with the exception that the relay coil is in series with the output.

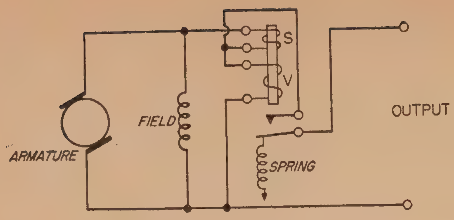


Fig. 12. The cutout relay consists of a dual winding coil with the relay reacting to both current and voltage. Normally the coils act together to hold the relay closed. When the generator voltage falls below a certain level the current through coil "S" will flow in a reverse direction, bucking the current (and pull) of coil "V" allowing the spring to pull the relay open.

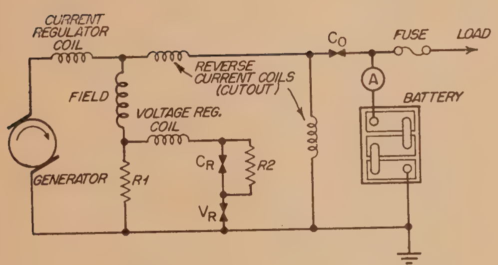


Fig. 13. Active components in a "3-unit" regulator.

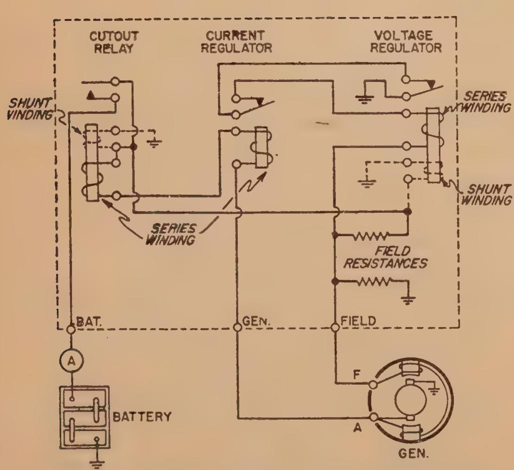


Fig. 14. Pictorial schematic of a typical regulator installation in most automobiles.

operation the armature of the voltage regulator should be held open so that it cannot be operated by its magnet.

Adjustment of the Voltage Regulator

The usual voltage regulator setting is barely high enough to keep the automobile battery fully charged under normal circumstances. The regulator is set at the factory to reduce the charging current to zero when the battery is not quite fully charged. With this adjustment the generator will not charge to full capacity until the battery drops to a half-charged condition. The battery will seldom rise above this point with ordinary city driving because of the tapering effects of the regulator. By adjusting the spring tension on the voltage regulator the "fully charged" current may be raised. If the regulator is adjusted to deliver about 10 amperes to a *fully charged* battery, the normal use of the mobile equipment will adjust a higher level of equilibrium and the battery will remain nearly fully charged at all times. On long trips, however, if the mobile equipment is not used to compensate for this higher charging rate it may be necessary to turn on the radio or headlights to prevent overchaging of the car battery. For the usual city driving of short duration this is not necessary.

The following are the adjustments to increase the charging rate. Be sure your battery is *fully charged* before making these adjustments:

1. Wedge the armature of the current coil so that it is inoperative.
2. Speed the engine and note at which current point the action of the voltage regulator levels off the charging current. (The current should be measured on a 0-50 d.c. ammeter placed in series with the heavy charging lead from the battery to the generator.)
3. Adjust the spring tension on the voltage regulator relay until this levelling action occurs at a charging rate of 10 amperes. Make this adjustment carefully, changing the spring tension slowly. This levelling action occurs at a charging voltage of 7.2-7.3 volts.

These adjustments should only be done after the underhood temperature is up to normal. Most regulators have temperature compensating hinges and all adjustments must be made with the regulator at operating temperatures.

Correct setting of the voltage regulator will be denoted by a specific gravity reading of 1.250 to 1.275 of the battery at all times, and by little use of water. Under ideal conditions the car ammeter needle should move to full charge immediately after starting the car, and remain there for perhaps five minutes, then fall to a minimum charge determined by the spring adjustment described above.

Operate the vehicle for a week or so, then

check the specific gravity of the battery again. If it is in the range of 1.250 to 1.275, and the dashboard ammeter behaves as described above, the job is finished. If the gravity is too low, recheck the leveling action, and perhaps adjust it at a slightly heavier rate, say 12 amperes.

Care of the Car Battery

The operation of the automotive type storage battery is a chemical reaction involving lead, lead oxide and sulfuric acid. During discharge the above components recombine to form lead sulfate and water. The water formed dilutes the sulfuric acid electrolyte, thus reducing the specific gravity of the cell. On charging, the chemical reaction is reversed. When the battery is overcharged beyond the point necessary to complete the chemical reaction, the water content of the electrolyte is reduced by electrolytic decomposition. Hydrogen is liberated at the cathode while oxygen is liberated at the anode; both of these gases bubble from the liquid and are lost, thereby necessitating the water additions.

The capacity of a battery to store electrical energy is controlled by the quantity of ingredients available for chemical reaction: i.e., the size and number of plates. The ability of the battery to deliver high rates of current flow is limited by its internal resistance. This is proportionate to the plate area. Thus it can be seen that the larger physical-sized units store more energy and can deliver it at higher rates than smaller units.

It must be borne in mind, however, that even a large size automotive-type battery stores a surprisingly small amount of energy. For example, a fully charged De Luxe battery of 120 ampere-hour rating would operate the modern car with its high electrical load only about 1 to 2 hours before becoming exhausted. This dramatically illustrates the fact that, in your car electrical system, the battery really plays a relatively unimportant part since without charging equipment its life would be woefully inadequate.

The greatest portion of battery failures occur during cold weather. The reason for this can be readily seen by referring to *Figure 15.* This curve shows the effect of temperature on battery capacity.

The first 20° F. day of fall reduces the capacity of your battery to approximately 2/3 of normal. Further, if your battery was only half charged to begin with, this capacity falls to only about 20% of normal! This reduction can be seen from the curves of *Figure 16.* The obvious moral of this story

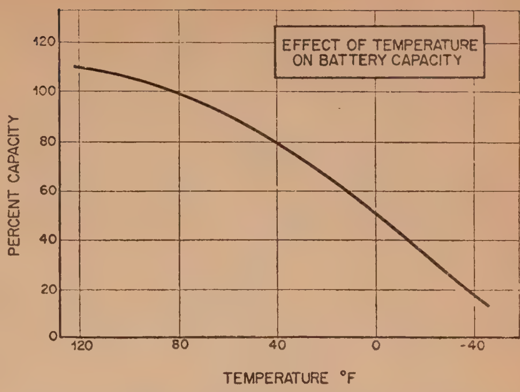


Fig. 15. Battery temperature has a pronounced effect upon battery capacity. This graph shows the decrease in capacity as related to temperature.

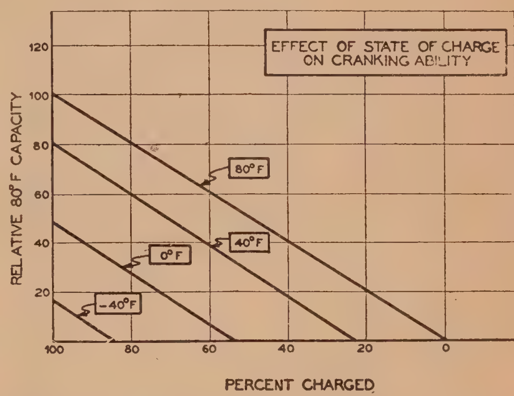


Fig. 16. The effects shown in Fig. 15 were measured for a fully charged battery. If the battery has only a partial charge the effects of low temperatures may be even more disastrous.

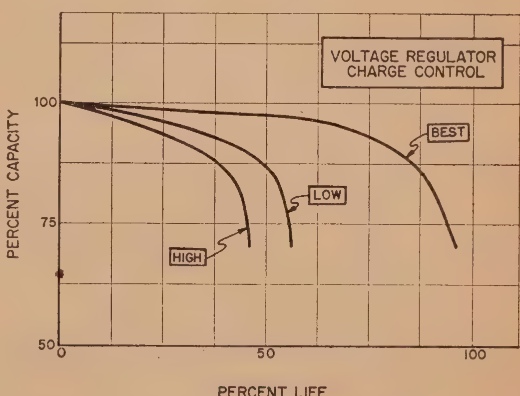


Fig. 17. The voltage regulator setting has an important influence on battery life. Too high, or too low, a setting may result in a substantial loss of battery life.

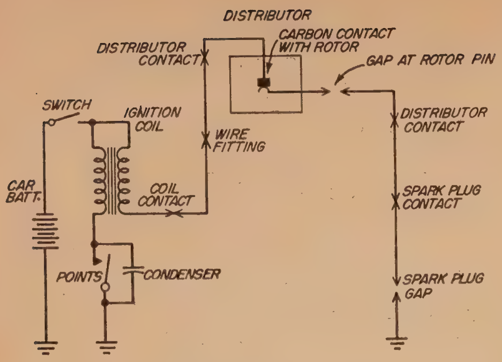


Fig. 18. Simplified ignition circuit.

is—*keep your battery fully charged at all times.*

In addition to the ability of the battery to crank your car at any given moment, the correct state of charge has an important influence on the life of your battery as illustrated in *Figure 17.* Here it can be seen that either too high a regulator setting causes undercharge or sulfation, reducing battery life about 50%.

Recently, a major battery manufacturer made a survey of junked car batteries to determine the cause of failure. The results of this survey are given in the table below:

Still Serviceable	13%
Overcharged	55%
Sulfated	18%
Cracked Separators	3%
Container Failures	10%
Manufacture Faults	1%

Examination of this table reveals the following fact: that 68% of the batteries checked failed as a result of malfunction of the *other* components of the car electrical system; a cause that could have been readily avoided by adequate maintenance. Your part in this effort is to keep the battery water level as called for by the manufacturer, to keep the battery clean and properly fastened in its carrier, and finally, to keep the charging equipment in proper adjustment.

Battery Maintenance

1. The electrolyte in the battery should be maintained at the proper level. It should be checked at least once a month in winter, every two weeks in summer, or every 1000 miles.
2. Do not overfill the battery.
3. The charge of the battery should be checked frequently with a hydrometer. The state of charge is indicated by the reading:

1.250-1.300	:	Fully charged
1.225	:	Half charged
1.150	:	Very low

4. A fully charged battery will not freeze in temperatures usually encountered. A battery with 1.150 specific gravity will freeze at 5° F., and a battery with 1.100 specific gravity will freeze at 18° F.
5. The terminal connectors of the battery should be removed, cleaned and inspected regularly. The connections must be secured tightly when replaced, or excesively high generator output may cause damage to the ignition system.
6. Apply a coat of vaseline or petroleum jelly to the terminal connectors of the battery to protect them from corrosion.

the Ignition Circuit

The ignition circuit of the automotive electrical system is briefly shown in *Figure 1.* A

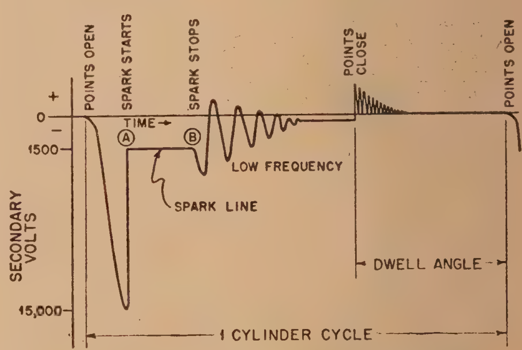


Fig. 19. Analysis of the secondary waveform.

simplified secondary circuit comprising the high voltage system is shown in *Figure 18.* The pulsating primary voltage developed by the distributor points opening and closing is transformed in the ignition coil to a level of about 20,000 volts. This voltage is passed through a simple series circuit to the distributor. The distributor and breaker points are located in a phenolic inclosure and are driven from the engine crankshaft.

The secondary circuit voltage is illustrated in *Figure 19.* The correct spark plug is chosen by distributor action, and the secondary voltage rises rapidly, reaching peak value in about .006 second. As this voltage increases, it eventually reaches a potential sufficiently high to break down the spark plug gap, causing an arc to strike. The arc-striking voltage may vary from 2000 to 15,000 volts depending upon leakage losses in the secondary circuit, and the age and condition of the plug. The striking voltage is also a function of the amount of compression created by the motor. Once the arc is struck, however, it requires only a small voltage to maintain it, usually about 1500

volts. The voltage curve of *Figure 19* drops rapidly from the peak level to the 1500 volt firing level (line A-B). The arc current continues to flow across the spark plug gap, finally going out at point "B," corresponding to about 10° of crankshaft rotation from the starting point. A series resonant oscillation resulting from the abrupt cessation of current flow now occurs in the secondary circuit. The frequency of osillation is a function of the secondary inductance of the ignition coil and the residual circuit capacity.

A second transient is created when the distributor breaker points close, lasting about one-half the period that the points are closed. This period is referred to as the *dwell angle*.

The purpose of the ignition coil is two-fold: First, it converts battery stored energy to magnetic stored energy during the dwell period. Second, it converts the magnetic stored energy to a high voltage sufficient to arc across the spark plug, thereby creating heat energy to fire the fuel.

The ignition condenser also serves a dual purpose: First, it balances the inductive effect of the coil so that the coil-condenser combination appears as a resistive load, thereby reducing or eliminating arcing at the breaker points. Second, it causes a rapid decay of primary current and therefore a high rate of decay of magnetic field strength, which produces a very high secondary voltage.

Occasionally, due to the condition of the spark plugs, engine factors, etc., the spark may actually strike and quench several times during its life. Should this occur, high frequency harmonics are generated each time the arc restrikes thereby seriously complicating the radio noise pattern of the ignition system.

Alternator Systems

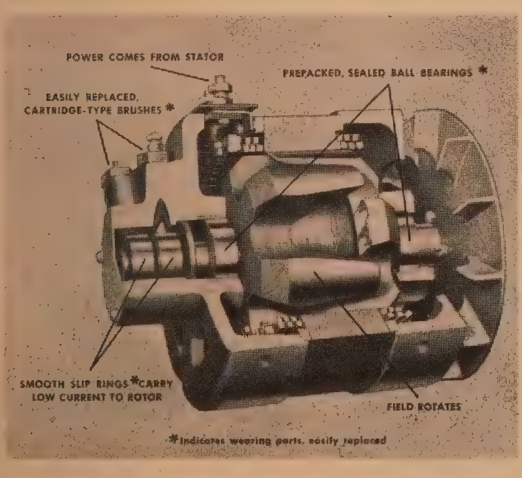


Fig. 20. The Leece-Neville 600 watt mobile alternator. Cutaway view, showing important parts.

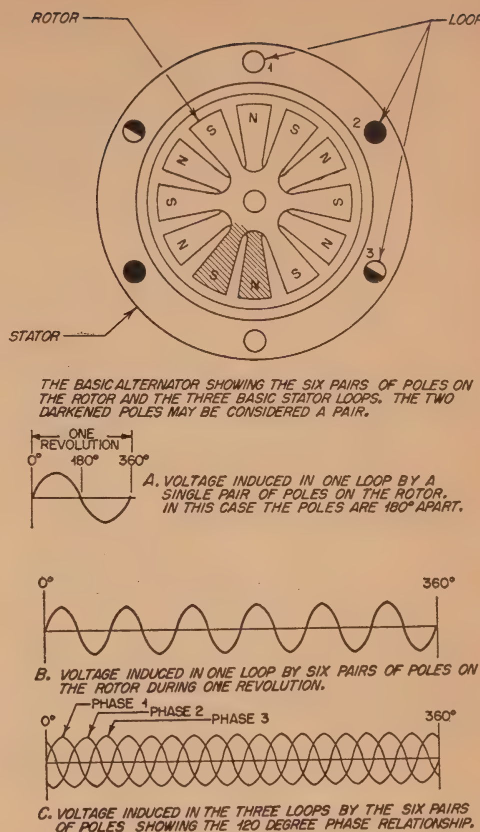


Fig. 21.

The automobile electrical system presents many problems when an attempt is made to operate radio equipment of more than minimal power requirements. Mobile alternators have provided a convenient way to increase primary power with a minimum of complications.

Theory of Operation

Mobile alternators produce low voltage, high current three-phase a.c. power. This power is then rectified and may be used to charge the battery, and to run accessories and radio equipment.

Figure 20 shows the inside of a Leece Neville alternator. In this unit, excitation is applied to the brushes, which in turn excites the rotor. The low excitation current, which is collected by *smooth* sliprings, eliminates hash generation. The rotating field then generates the a.c. in the *stator* windings. Hence the output is not commutated, but rectified by a metallic rectifier.

Figure 21 illustrates the theory of the a.c. alternator. If the rotor contained a single pair of poles (indicated in black) only one cycle would be generated during one revolution in any one loop. In the Leece Neville alternator there are six pairs of loops on the rotor. Therefore during one revolution six cycles will be

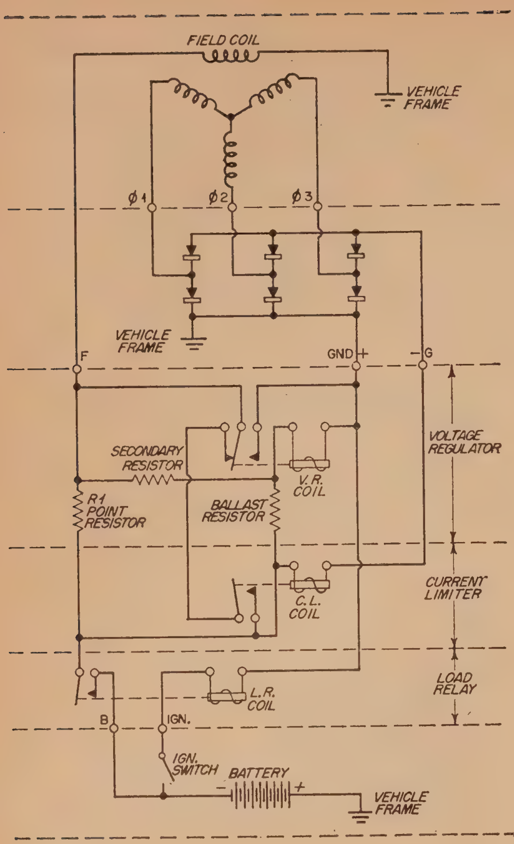


Fig. 22. Complete circuit for Leece-Neville system. Special attention should be paid to polarity of components.

generated in one loop. Now if loops 1, 2, and 3 are 120 degrees apart the voltages induced in these loops will be 120 degrees out of phase with each other. This unit is called a three phase alternator because it produces three separate a.c. voltages.

Units are available which produce 7 volts at 95 amps, or 14 volts at 50 amps. See *Figure 23* for ratings.

Rectification

The a.c. generated is rectified by a magnesium copper sulfide dry-disk metallic rectifier. This rectifier operates well at high temperatures, whereas the more expensive selenium rectifiers used in the 14-volt systems are more heat-sensitive, but more efficient. As these rectifiers are not affected by under-hood temperatures under 200°F, they may be mounted on the engine near the alternator. Since the a.c. is fed into a rectifier, the rotor of the alternator may be turned in either direction. Therefore the polarity of the rectified output is independent of the direction of rotation. Also, the positive or negative side of the rectifier output may be grounded to provide a positive or negative car ground. It should be noted that in connecting a rectifier to a battery, the polarities of each must correspond. A reversed connection will result in damage to the rectifier as excessive current will be discharged through it by the battery. With positive to positive, and negative to negative, the rectifier will block any discharge current when the engine is not running.

Regulation

Voltage and current regulation are easily achieved with the Leece-Neville alternator. The excitation voltage applied to the rotor determines the output of the alternator. Hence it is necessary to regulate the excitation voltage.

Voltage regulation is obtained by double contact regulators, shown in *Figure 22.* These regulators, patented by the Leece-Neville Co., operate within a narrow voltage range, decreasing the danger of burned out filaments in mobile gear. Arcing is reduced at the regulator as smoother regulation can be obtained.

When the moving arm of the voltage regulator (*Fig. 22*) is on the upper contact, full voltage is applied to the exciter winding. As the voltage increases slightly, the voltage regulator coil, which is connected across the output, is just strong enough to pull the arm off the top contact, but not to the bottom position. The voltage applied to the exciter winding is then reduced, due to the point resistor *R1*. Should the voltage tend to further increase at high speeds the voltage coil is able to pull the moving arm to the bottom contact which shorts out the exciter winding. Therefore at slow speeds the arm will vibrate on the upper contact, and at high speeds on the lower contact.

The current regulator protects the alternator and rectifier by limiting the current output of the alternator. The coil of the current regulator is connected in series with the ungrounded side of the output circuit. When the current exceeds the rating of the unit the coil pull will be

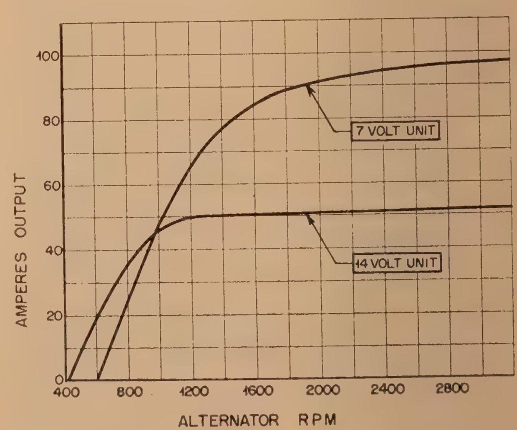


Fig. 23. Current output vs. rpm for the two popular voltages in Leece-Neville units.

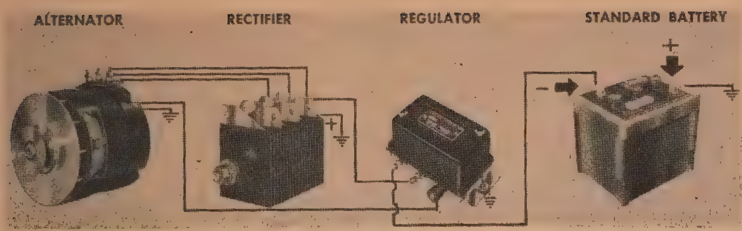


Fig. 24. Pictorial view of Leece-Neville Alternator Installation.

strong enough to cause the moving arm to vibrate, inserting enough resistance in the field to limit the output to the proper level.

The load relay, which is energized by the ignition switch, disconnects the alternator system from the battery when the car is not in use.

It should be mentioned at this point that a distinct advantage of these alternators is their high output at motor idling speeds. Forty-five amperes may be generated while idling, which is extremely useful during active communication (*Figure 23*).

Maintenance

A minimum of maintenance is necessary as the alternators are ruggedly constructed. The bearings are of the sealed ball bearing type which require no lubrication, and which may be replaced if necessary. Likewise, the rotor field coil, the rotor shaft, the slip rings, and the brushes may be easily replaced if damaged. The brush life of an alternator, however, is much longer than that of a generator as a result of the low current commutation. Since all moving parts may be replaced the alternator may be used in the lifetime of many cars.

Wiring harnesses are available for the Leece-Neville alternator which may be obtained from the company. If an installation is to be made without a harness, good automotive cable should be used that will stand up under engine temperatures and will be of sufficient size to carry the full output of the system. The complete installation schematic is shown in the pictorial photograph above, (*Figure 24*).

Alternator Summary:

It may be more clearly understood now that mobile alternators have certain outstanding advantages with respect to other systems:

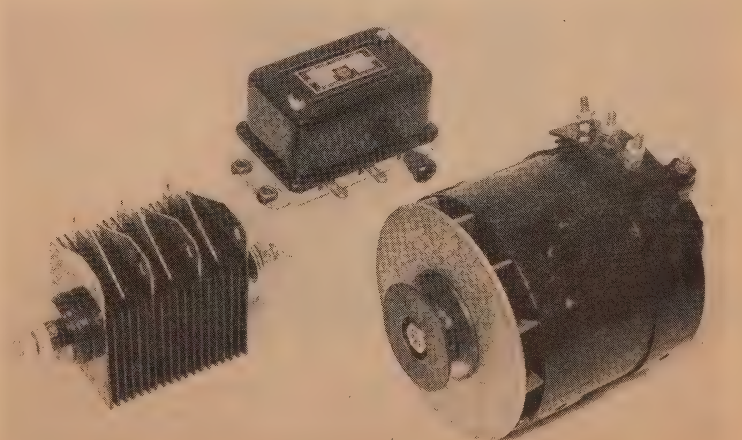
1. Smaller physical size, greater power output.
2. No high current commutation, no arcing, no hash.
3. Rotation reversible; positive or negative car ground.
4. Smooth voltage regulation, reduced arcing at contacts.
5. Good output at idling speeds.
6. Exceptionally long life.

With the increasing availability of these units they are becoming very popular in amateur mobile installations.

110-Volt A.C. Systems

The a.c. output of the alternator may be stepped up to 110-volts by means of suitable transformers, and conventional electrical equipment may be run directly from the system. This is a very important feature of the rectified a.c. system, since the initial high cost of the alternator may be partially offset by the elimination of the dynamotors and vibrator supplies usually needed to provide plate potentials for the radio equipment. Ordinary good quality 60 cycle transformers will work well when connected to the alternator, in spite of the higher fre-

Fig. 25. The components of the Leece-Neville Installation. At the left is the dry-disc rectifier used for charging the car battery from the a.c. supply. Above it is the voltage regulator for use with the rectifier. At the right is the a.c. belt-driven alternator.



quency output of the alternator. Typical a.c. systems are discussed in Chapter 2 of this Handbook. The alternator system of W8GGG is shown in *Figure 26*.

Three Phase Mobile Supply

The three phase output from a Leece-Neville system may be employed to provide some 300 watts of power, in addition to the job of charging the automobile battery. Power levels of 600 watts or so require special three-phase transformers, whereas the 300 watt level may be utilized with the aid of some 6.3 volt filament transformers. Each phase of the alternator is employed to excite one filament transformer that is connected up "backwards". That is, the output of the alternator is applied to the filament winding, and the high voltage is taken from the 110-volt "primary". This 3-phase output is passed through a group of full-wave selenium voltage doublers, and the d.c. outputs of the three full-wave systems are connected in series to provide a high voltage supply of 750 volts at a current drain of 400 milliamperes. Because of the high ripple frequency of the 3-phase supply, no additional filtering other than the condensers in the individual voltage doubler circuits is required.

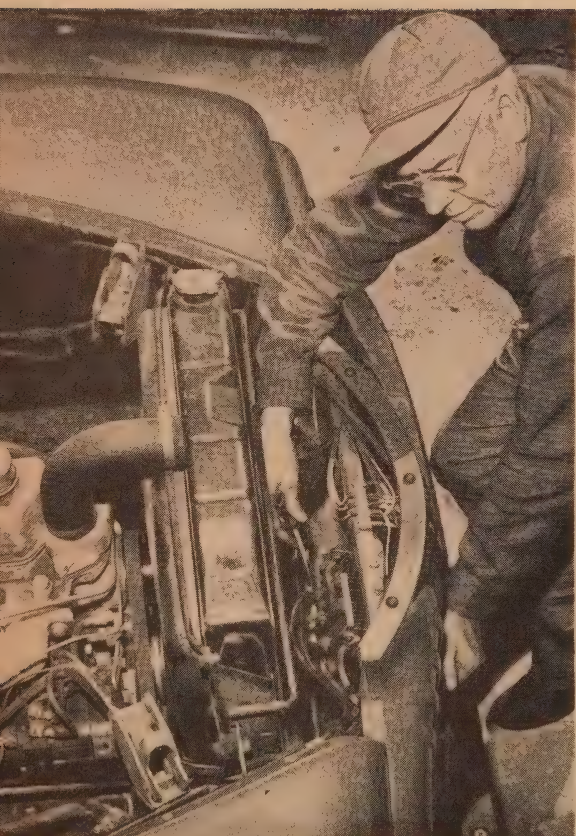


Fig. 26. The Leece-Neville installation of W8GGG. The alternator is in the lower left of the photograph. The rectifier is located in front of the radiator, directly behind the grille of the car.

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Chapter Two

Mobile Power Supplies


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Mobile Power Supplies

Unlike fixed equipment, mobile transmitters must be designed to fit specific power supplies. Mobile supplies, such as dynamotors or vibrator packs provide fixed voltages at certain current limitations. One cannot add an input condenser to the filter supply to boost the available voltage, or merely put in a larger power transformer to supply more current. A change of supply voltage in mobile work usually necessitates a completely new source of power. This is expensive, so it is necessary to design the mobile equipment around some rather standardized voltages and currents that are readily available.

Two popular sources of high voltage supply are the dynamotor and the vibrator supply. Let us examine each of these sources of supply, and determine under what circumstances it is wise to use each of them.

VIBRATOR POWER SUPPLIES

The basic design of a vibrator type power supply consists of a common a.c. operated supply, with an interrupted d.c. primary voltage supplied by a battery and a chopper. The chopper (or vibrator) makes and reverses the primary circuit of the power supply about 100 times per second. The alternating field produced in the power transformer primary circuit induces a square wave alternating voltage in the secondary windings. This voltage may be rectified and filtered as in the usual high voltage supply.

Two types of vibrators are in common use. The simplest is the non-synchronous type, illustrated in *Figure 1*. Upon application of battery power the vibrator magnet coil is energized and pulls the flexible reed towards contact 3. This contact produces a pulse of voltage in one half of the transformer primary winding. At the same time, the magnet coil is short circuited by the contact and the magnet is de-energized, allowing the reed to swing back and touch contact 2. This contact causes a pulse of voltage in the other half of the primary winding. Simultaneously, the magnet coil is energized, causing the cycle to repeat itself. The *T1* secondary output voltage is shown in *Figure 2*.

The second type of vibrator (*Figure 3*) is the synchronous type, equipped with double contacts. The second set of contacts, operating on the high voltage secondary, act to rectify the secondary square wave voltage. This mechanical rectifier eliminates the high voltage rectifier tube. The positive high voltage is taken from the transformer center tap, and the transformer windings must be correctly polarized.

For either type of vibrator a buffer condenser is needed across the full secondary winding. This condenser absorbs the inductive surge of the power transformer and reduces sparking at the vibrator contacts. The correct value of this condenser is the one which results in the lowest value of primary current drain when the vibrator supply is operating under full load. The condenser should be rated at 2000 volts d.c. for the usual 300 volt supply. A 5000 ohm 1 watt resistor should be placed in series with the condenser to protect the transformer and vibrator in case of failure of the condenser.

Vibrator Noise Suppression

A vibrator supply is a prolific r.f. noise generator. The commercially manufactured vibrator supplies are carefully filtered and shielded to minimize this noise. A home made supply should have the following included for maxi-

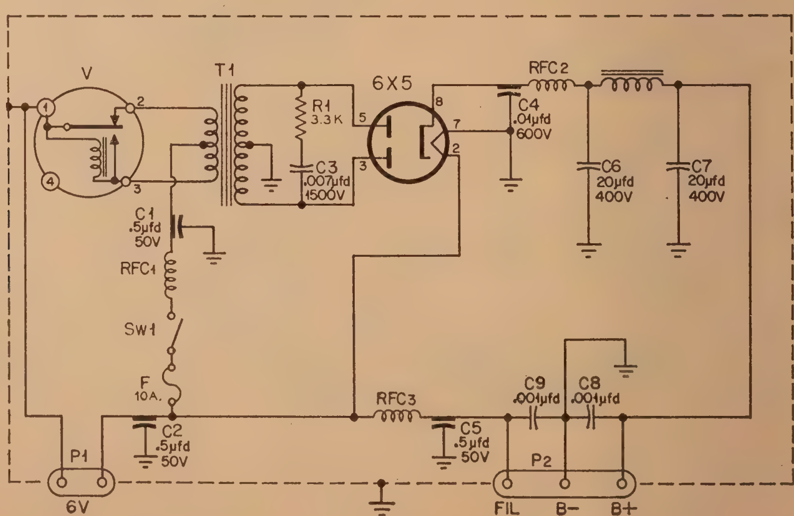


Fig. 1. Wiring schematic of a non-synchronous vibrator power supply. Note that the entire unit must be thoroughly shielded for maximum "hash" suppression.

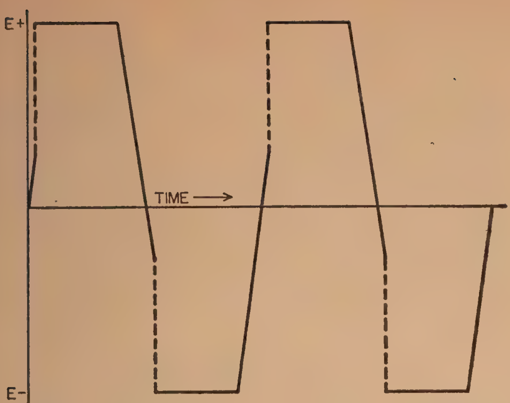


Fig. 2. The voltage waveform in the transformer secondary circuit appears to have the shape indicated above when the timing capacity is properly set.

mum suppression of noise:

1. The supply should be built on a metal chassis with a bottom plate. All unshielded components should be mounted beneath the chassis.
2. Primary and secondary r-f filters should be used, consisting of chokes and low inductance condensers.
3. The vibrator shell and transformer case should both be securely grounded to the chassis. A metal rectifier tube should be used. If a glass tube is used, it should have a grounded tube shield placed over it.
4. The primary supply leads should be twisted and shielded, with the shield grounded at each end of the leads.
5. The chassis of the supply should be grounded to the car.

A schematic of such a supply is shown in *Figure 1*. The operating characteristics of a typical vibrator supply (Mallory VP-552) are shown in *Figure 4*.

Operating Tube-Rectifying Vibrator Power Supplies on 115 Volt AC Lines

Some vibrator transformers are equipped with a special 115 volt primary winding. If the vibrator is removed, the supply may be used on 115 volts, a.c. The additional winding is expensive and takes up room on the transformer core, so most vibrator transformers do not have it. The absence of this winding, however, does not prohibit the use of the vibrator supply on an a-c line. If a step-down transformer which will supply 10 volts a.c. at the load current required is available, easy adaptation of standard 6-volt tube-rectifying vibrator power units will be possible. The 10 volts a.c. is applied to the vibrator transformer *across the entire primary winding* by removing the vibrator and inserting an adaptor having the 10 volts connected to the two small pins of the standard vibrator base, or to the equivalent pins of an unconventional base, if one is used. The value of 10 volts is used instead of 12.6 volts, because of the difference in waveform between the sine-wave a.c. and the square wave d.c. The tube heaters may be run from the 10 volt source through a suitable dropping resistor. A 20 volt transformer should be employed for operation of a 12 volt vibrator supply from an a-c source.

The operation of a vibrator supply on an a.c. line is a great help during the testing and trial runs of new equipment.

A VIBRATOR SUPPLY USING SELENIUM RECTIFIERS

A novel and highly efficient vibrator supply may be built using a selenium rectifier in the place of the usual high voltage vacuum rectifier tube. The selenium voltage doubler has several advantages over the tube rectifier which make it very worth while for mobile use:

1. In a typical vibrator supply, such as shown in *Fig. 1*, only half the transformer is in use at any one time. It is possible to make full use of the transformer by using the half-wave doubler circuit shown in *Fig. 5*. The secondary winding of such a transformer requires only 70% of the space required for the equivalent output from a center tapped full wave secondary winding.
2. The use of selenium rectifiers offers improved voltage regulation, as compared with vacuum rectifiers, since the forward resistance of the selenium rectifier is extremely low. The regulation of this supply, compared to a vacuum tube rectifier supply is shown in *Fig. 6*.

Components

The special vibrator transformer used in this supply has a high voltage winding rated at 160 volts and 100 milliamperes. A tapped primary winding is provided for either 6 or 12 volt operation. A separate winding allows 115 volt a.c. operation. Filament voltage for a.c. operation

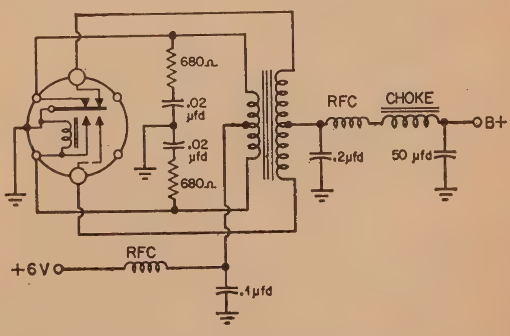


Fig. 3. The synchronous vibrator power is self-rectifying due to the use of a double set of vibrator contacts. Through proper polarization of the transformer windings this mechanical rectification is possible.

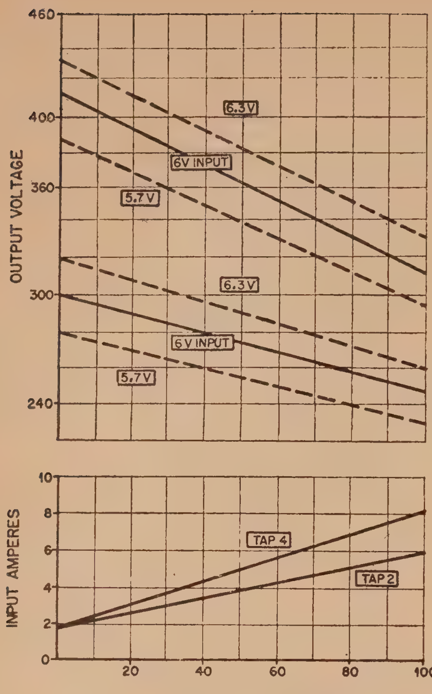
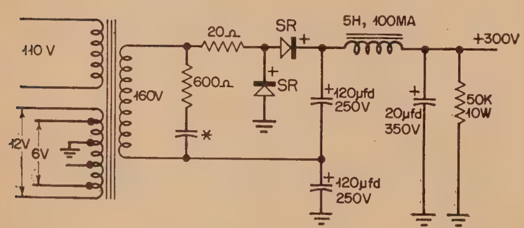


Fig. 4. This family of graphs shows the operating characteristics of the VP-552 Vibrapack. *(Courtesy P. R. Mallory & Co.)*



** – ADJUST FOR MINIMUM PRIMARY CURRENT AT MAXIMUM SECONDARY LOAD. USE 1 KV CONDENSER.*
SR – INTERNATIONAL RECTIFIER CO. – RS100

Fig. 5. Voltage-doubler selenium rectifier circuit suitable for mobile application.

is provided by a 6.3 volt tap on the "d.c." primary winding. This tap is used only when the supply is run on alternating current.

Vibrator Life

Vibrator life is usually a compromise between output and the effects of heating and sparking at the contacts of the vibrator. The proper secondary buffer condenser is extremely important in obtaining maximum vibrator life.

For mobile transmitters, where the "off" period is large compared to the "on" period, overloads of 50% or so seem to do little harm to the vibrator. Several heavy-duty vibrator units are on the market for the amateur who is interested in building his own vibrator supply. The *Radiart 5506* is rated for 60 watts continuous duty (6v.) and the Mallory 6VL10 may be used at loads up to 125 watts in intermittent duty (6v). In a suitable voltage doubling circuit, this vibrator can supply 500 volts at 200 ma., and 250 volts at 100 milliamperes simultaneously. The high voltage may be used to run the r.f. amplifier and modulator of a 50 watt transmitter, and the low voltage may be used to supply the speech amplifier and r-f exciter stages.

DYNAMOTORS

A dynamotor is a motor driven d-c generator which converts low voltage direct current to high voltage direct current. Unlike a motor generator, the low voltage and high voltage windings of the dynamotor are mounted on and around one shaft as an integral unit. The efficiency of a good dynamotor is slightly less than that of a vibrator power supply, running about 55-60%. This is because the dynamotor must draw enough extra power from the primary source to keep the armature rotating.

Dynamotor Maintenance

If the dynamotor is operating properly and does not run excessively warm, it should rarely be touched. Sanding of the commutator, manipulation of the brushes or excessive greasing is likely to do more harm than good.

A routine inspection once every two weeks should consist of a check as to whether or not the brushes are free in their holders, and a cleaning of the carbon or copper dust which may have accumulated in the vicinity of the commutators. If the voltage output is below normal remove the brushes and check each coil winding of the armature for an open or short circuit. This is accomplished by placing the prods of an ohmmeter on adjacent high voltage commutator bars and continuing the test around the commutator. The prods should not be applied to the commutator surface that comes in contact with the brushes. The high voltage windings will have a resistance in the range of 5-30 ohms. The low voltage windings must be measured on a bridge, as they run only a few tenths of an ohm. The d-c resistance of the shunt field is of the order of 100 ohms or so.

Brushes

Low voltage brushes have a useful life of about 1000 hours of operation. High voltage brushes should last somewhat longer. The end of the useful life of the brushes comes when they have worn down to a length of about ¼″. When new brushes are installed, the commutator should be carefully sanded with grade 0000 or finer sandpaper. The dynamotor should be "run in" for about six hours until at least 80% of the surface of the new brushes is in contact with the commutator.

Operation

The dynamotor should be operated with adequate ventilation. Most dynamotor failures occur because of overheating caused by overload or inadequate ventilation. If the dynamotor is located in the turtleback of an automobile the operating temperature will quickly exceed the danger point during warm weather. To help cool the dynamotor, the end bells should be removed. A small, 6-volt fan so located as to pass air thru the interior of the dynamotor will also help in keeping the operating temperatures in the safe region.

THE PE-103A DYNAMOTOR

The surplus PE-103A dynamotor unit is well suited for use in a medium power mobile installation. It is a dual input voltage unit, delivering some 90 watts of high voltage power at an average efficiency of 55% from either a 6 volt or 12 volt d.c. primary source. The nominal rating of the PE-103A is 500 volts at 150 milliamperes. For intermittent amateur use, up to 275 milliamperes can safely be drawn for short periods of time. The voltage and current curves for the PE-103A are shown in *Figure 9*. The output voltage will vary slightly from the curves shown depending upon the exact value of primary voltage and whether the car generator is charging or not.

The schematic wiring diagram of the complete PE-103A is shown in *Figure 10*. Two primary commutators are used, a heavy duty one for 6 volts and a second somewhat lighter one that is added in series with the 6-volt one for operation on 12 volts.

If the PE-103A is to be used only on 6 volts, it is wise to remove the 12-volt brushes to reduce the commutator drag. This will drop the primary current about 1 ampere.

The pin connections to the PE-103A are: (for 6 volt operation)

Plug: Cannon P8-CG-12S
Pin 1 = A-minus 6 volts
Pin 2 = Not used
Pin 3 = A-minus 6 volts
(on when dynamotor is running)
Pin 4 = Control circuit
Pin 5 = B–, A plus 6 v.
Pin 6 = Not used
Pin 7 = A minus 6 volts
Pin 8 = B plus 500 v.

For 12-volt operation the pin connections are:

Pin 1 = Not used
Pin 2 = A minus 12 volts
Pin 3 = A minus 6 v.
(on when dynamotor is running)
Pin 4 = Control circuit
Pin 5 = B–, A plus 12 v.
Pin 6 = Not used
Pin 7 = Not used
Pin 8 = B plus 500 v.

For either 6 or 12 volt operation connecting pin 4 to pin 5 will start the dynamotor.

Operation of the PE-103A

Referring to *Figure 10:* The 6v-12v switch *3S1* is on 12 volts, the circuit breakers are closed and the relays are not energized. Connection to the battery is made through two heavy cables, and connections between the PE-103A and the equipment is made through an 8 conductor receptacle mounted on the PE-103A control box (Cannon P-8-41).

When the control circuit (pin 4) is connected to the B minus (pin 5) relay *3E6* is energized. One pair of contacts on this relay energizes the 6 volt starting relay *3E2* through the *3E3* and *3E4* circuit breakers. These are high and low

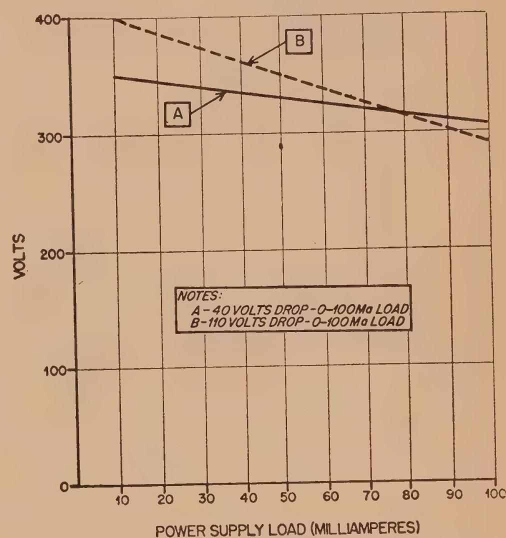


Fig. 6. Regulation of selenium voltage doubler supply (A) compared to conventional vacuum tube full-wave supply (B).

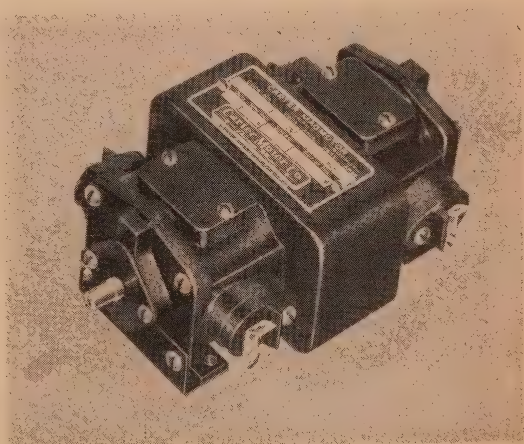


Fig. 7. For low power consumption a Carter Magmotor is often the most suitable high voltage supply.
(Courtesy Carter Motor Co.)

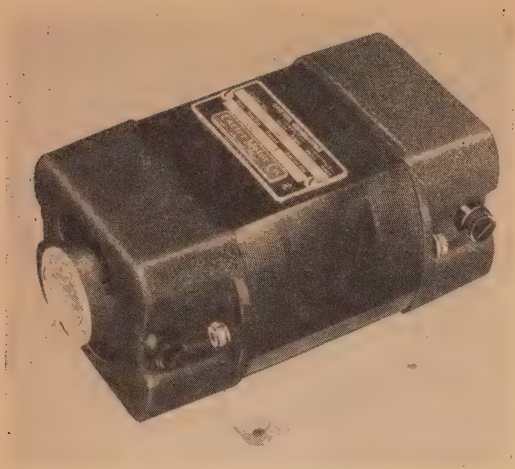


Fig. 8. This 3-inch frame genemotor is very popular in mobile radio installations.
(Courtesy Carter Motor Co.)

voltage circuit breakers respectively. If any of these circuit breakers open the dynamotor will stop. The high voltage breaker will open at about 220 milliamperes, and the 6 volt breaker will open at 40 amperes primary current. If a 12 volt battery is accidentally connected to a PE-103A set for 6 volts, relay *3E7* will close and open breaker *3E5,* disconnecting the battery and protecting the dynamotor. Pin 3 supplies 6 volts to operate an external antenna relay.

(Note: Units having serial numbers below #4711 have no high voltage circuit breaker and the B plus is connected to pin 3 instead of pin 8.)

Condensers *3C9* and *3C10* bypass r-f currents to ground.

Condenser *3C2* is a ripple filter for the 6-volt armature.

Condensers *3C1, 3C4, 3C5, 3C6, 3C11* and choke *3L1* constitute a hash ripple filter for the high voltage armature.

For 12 volt operation, relay *3E1* is the 12 volt starting relay. Resistor *3R1* drops the 12 volts to 6 volts to operate the control relay *3E6.* Resistor *3R3* drops the 12 volts to 6 volts to operate an external antenna relay. Pins 6 and 7 provide a dropping network to supply 6 volts to the filaments of certain tubes in the SCR-284 radio set and are of no use in amateur operations with the dynamotor.

Modifications of the PE-103A

Several slight modifications are desirable for amateur use of the PE-103A:

1. If no 12 volt operation is intended the 12 volt brushes should be removed. Also, relay *3E7* should be removed from the circuit by disconnecting the heavy relay lead terminating at the "plus" primary terminal. This will prevent a constant 15 milliampere drain from the automobile battery if the circuit breakers are left on.
2. The high voltage circuit breaker *3E3* is very sensitive and is liable to cut out on a heavy modulation peak. Shunt a 47 ohm 1 watt resistor across the breaker coil. The breaker will now cut out at about 260 milliamperes.
3. There are three available pins for the filament return: pins 1, 3 and 7. Pins 1 and 7 are in parallel and are in series with breaker *3E5* which will open at a load of 7.5 amperes. Pin 3 is also in series with *3E5* and also in series with

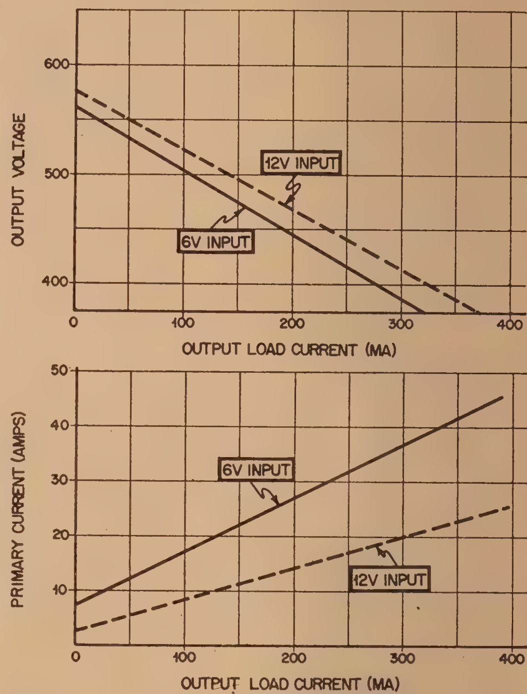


Fig. 9. These two graphs show the output voltage and primary current of the PE-103A dynamotor as a function of output load current.

   3E6 the control relay. This pin may be used for the filament circuit of instant heating tubes since the filament voltage comes on at the same time as the high voltage. In all cases, pin 5 is the filament return pin. When 12-volt tubes or relays are used for 12-volt operation resistor *3R3* must be shorted out.
4. When the PE-103A is used in an automobile the negative of whose battery is grounded to the car, the high voltage commutator should be switched. The wires on the high voltage positive brush should be removed and connected to the negative brush. The negative brush wires should be connected to the positive brush. The positive battery cable then goes to the negative of the battery terminal, and

the negative cable is connected to the positive battery circuit.

Starting Current

The starting current of a dynamotor is several times greater than the full load running current. The PE-103A has a starting current of 150 amperes. This surge is only of a few seconds duration but if it occurs in a rapid sequence such as is possible in break-in phone operation it will be sufficient to cause quite a heating loss in the power leads and in the dynamotor itself. The dynamotor should not be located near the car motor because of the heat radiated by the motor. Also, if the dynamotor is located in the trunk of the car the end bells of the dynamotor should be removed to improve the circulation of air through the dynamotor.

A ground lead should run directly from the battery to the dynamotor. Never use the chassis of the car for a power return.

Control Circuits for the PE-103A

The PE-103A dynamotor has complete control wiring in the base in addition to low voltage, high voltage and filament circuit breakers. *Figure 11* shows a suitable transmitter control circuit that makes effective use of the inherent control wiring of the PE-103A. A small control panel containing a "Filament ON" switch and pilot lamp, a "Transmit" switch and pilot lamp, and a microphone jack will activate the complete mobile installation. When the "Filament ON" switch is closed the transmitter filaments will light and the warning pilot lamp will come on. When either the "Transmit" switch is closed or the microphone control button pressed, the dynamotor starts and high voltage is applied to the transmitter and the "Transmit" light goes on. In addition, the antenna relay operates to apply the antenna to the transmitter and the receiver is muted by breaking its high voltage. When operation of the equipment is completed, the "Filament ON" switch is turned off. When the car is not in use, circuit breaker *3E4* on the PE-103A dynamotor should be opened as a safety measure.

A spare set of contacts on the antenna relay may be used to break the high voltage to the transmitter oscillator. Since the output of the dynamotor does not drop to zero the moment the primary power is removed there is a space of time during which the transmitter oscillator still runs while the receiver is in operation, thus blocking the receiver for a short interval.

MODIFICATION OF THE PE-101C DYNAMOTOR FOR AMATEUR USE

The PE-101C dynamotor is a multiple winding dynamotor shown in *Figure 12* in its original form. It has a large right-angle *Cannon* plug on the top, and a sealed-in-oil 800:1 gear reduction box on one end. The dynamotor was designed to operate on either 13 or 26 volts d.c. by placing the primary windings in either par-

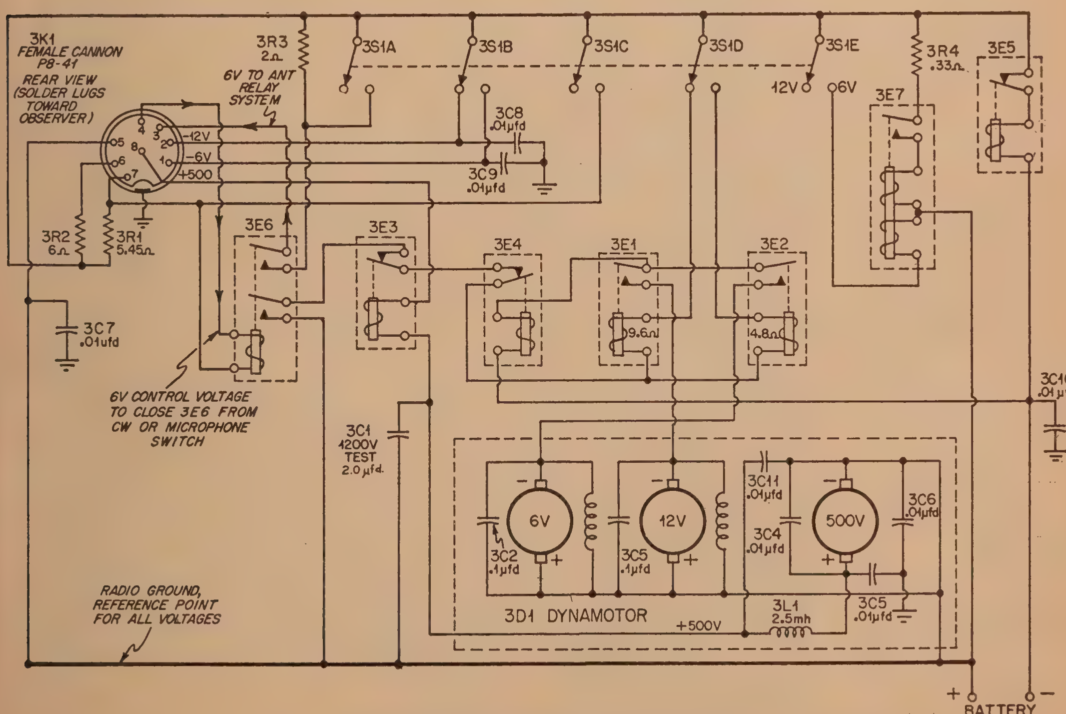


Fig. 10. Wiring schematic of the PE-103A.

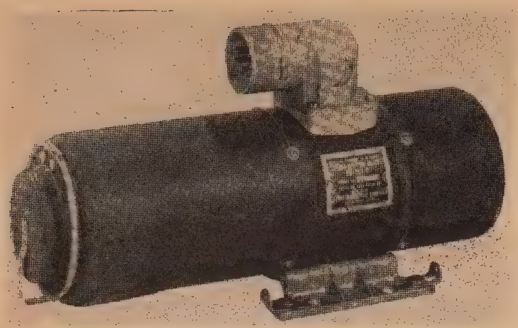


Fig. 12. The PE-101-C dynamotor as purchased in war surplus.

allel or series connection. The ratings given on the nameplate have no bearing as to the actual ratings of the dynamotor, they merely indicate the current drain of the unit as used as part of the BC-645 equipment for which the dynamotor was originally designed.

Figure 13 is a schematic diagram of the windings in the unit and their electrical relationship to each other. The primary wires are completely separate so there is no problem of positive or negative grounds. Two 400 volt windings are connected in series internally in the unit, and one end of one winding is grounded. The two windings are identical as to wire size and are both capable of carrying a load from each tap of some 125 milliamperes.

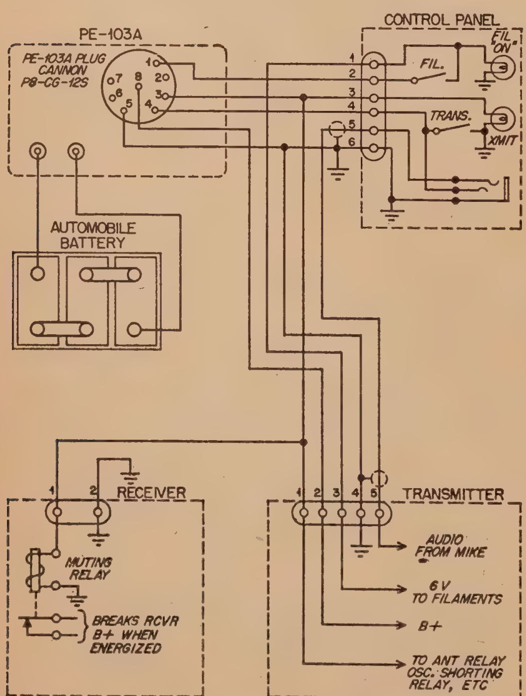


Fig. 11. This is a suggested control circuit to be used in conjunction with the PE-103A.

The unmodified dynamotor (connected for 13 volt operation) will work well on either 6 volts or 12 volts and delivers the following simultaneous outputs:

12 volts input	*6 volts input*
610 volts at 150 ma.	300 volts at 90 ma.
325 volts at 125 ma.	160 volts at 110 ma.

During a protracted run at the above loads the dynamotor did not get warm, indicating that these loads are not the upper power limit of the unit. The limiting factor of dynamotor life is the heat generated in the unit by friction and loss heating. If the dynamotor runs cool, it is running within ratings.

Conversion of the Dynamotor

Remove the safety wires holding the end bells. Loosen, but do not remove the eight end bolts. Open the cover on the long end and remove the four countersunk bolts which are visible. Slide both end bells off. With a pair of pliers remove the pin from the end of the armature shaft which connects to the gear box drive. With a long screwdriver reach in through the open side of the gear reduction box mounting bracket and remove the four bolts holding the gear box in place. Remove the gear box.

Take off the snap ring on the goose-neck plug and remove the top. Clip the wires close to the disc and tag them if the color code is not legible. Remove the entire top assembly.

Now, turn the dynamotor over and remove the mounting plate. Replace the bolts in their

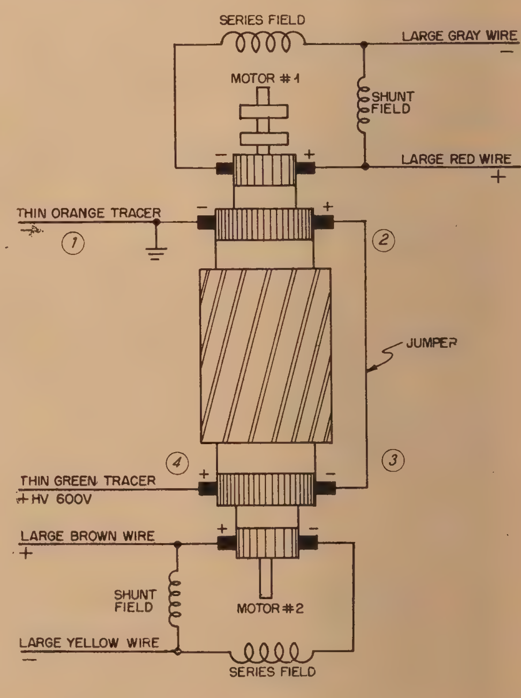


Fig. 13. Internal connections, PE-101-C dynamotor.

original holes, leaving the base off. With a sharp ½ inch drill carefully drill two holes in the base so that when the wires which are sticking out of the top of the dynamotor are fed through these holes the base will fit snugly up against the frame of the unit in its original position, but on the side from which the goose-neck was removed. The wires will now protrude through the holes that you have drilled in the base, which may be bolted in this position by enlarging the base holes in the proper direction so that they match the top-side holes. This may be done with the side of a drill or a small "rat-tail" file. The bolts which held the goose-neck should now be shortened a bit so that they will not interfere with the field winding inside the dynamotor. They are then used to bolt the base to the dynamotor.

Pull out the thin white wire marked *cam switch* and discard it. Remove the a-c brushes and their wires.

The long end bell should be cut down to reduce the overall size of the dynamotor since the reduction gear is removed. The bell is somewhat fragile, so care must be taken in this operation. There are two suggested ways:

1. Clamp the bell end in a vise and saw off the unwanted section with a hacksaw. Square the cut end on a sheet of coarse emery paper. Allow ½ inch extra to the length of the end bell to compensate for errors in cutting.
2. Chuck the end bell in a lathe and use a sharp cut-off tool to remove the unwanted section. A very slow cut must be made or the bell will collapse.

Replace the end bells on the dynamotor. This completes the conversion on the dynamotor. To make a neat job mount the unit on a 3″x5″x12″ chassis in which you can place the control relays, and the filters and wiring (*Figure 14*).

Control Circuit

For either six volt or twelve volt operation the low voltage windings on the dynamotor are placed in parallel. The brown and red leads are connected together, as well as the yellow and grey.

Figure 15 shows the complete control circuit for use with a 12-volt system. An extra battery is required for 6-volt cars. The 6-volt circuit of *Figure 16* places the two batteries in parallel for charging and in series for transmitting.

Relay *RY2* switches the batteries from series to parallel as the occasion demands. Under normal conditions the batteries are in parallel so that the auxiliary battery will be kept fully charged. When the press-to-talk button is depressed for transmitting, the relay operates and the auxiliary battery is placed in series with the regular battery and 12 volts is applied to the dynamotor. In the event low power operation of the transmitter is desired for initial tune-up, switch *SW1* is opened which disconnects the battery switching relay and applies only 6 volts to the dynamotor.

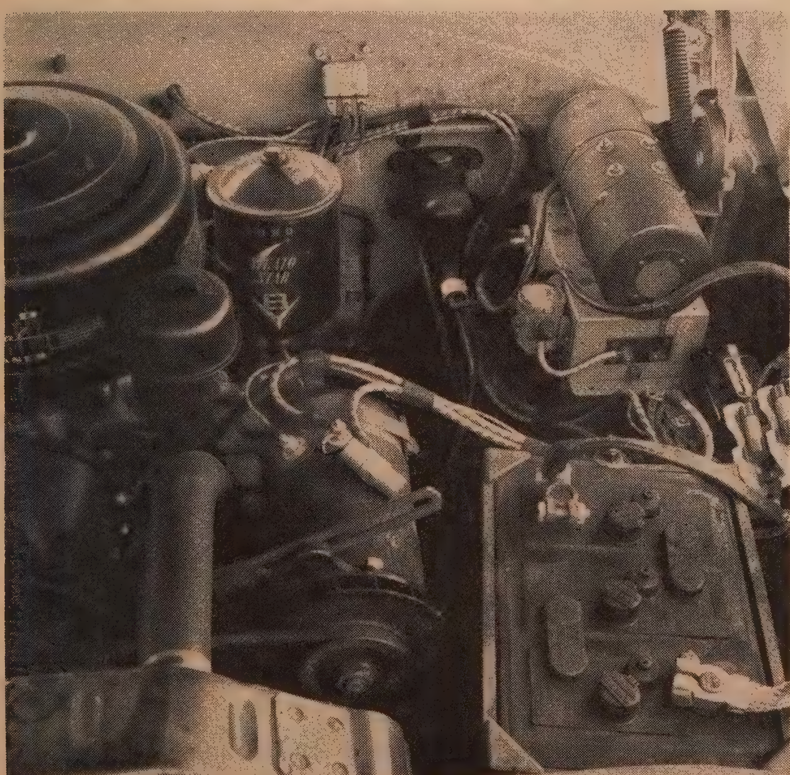
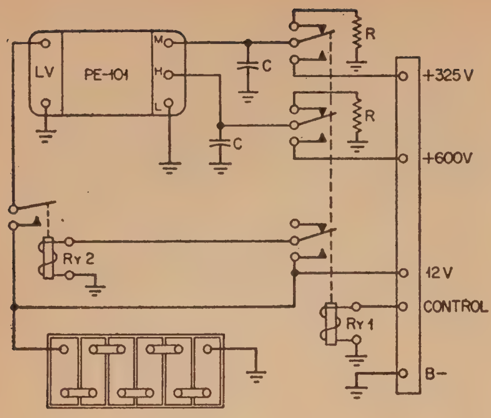


Fig. 14. PE-101C Dynamotor Installation. The dynamotor is mounted on a small metal chassis which is bolted to the car frame. A heavy duty 6 volt relay is mounted on the side of the chassis and is used to start the dynamotor. A 10 μfd. 600 volt filter condenser is used to filter the high voltage output of the unit. This condenser is mounted beneath the chassis.



C = 4 µfd, 600V OIL CONDENSER
R = 100,000 OHM, 1 WATT RESISTOR
Ry1 = 12 VOLT CONTROL RELAY, 3POLE DOUBLE THROW
Ry2 = 12 VOLT HEAVY DUTY CONTACTOR RELAY

Fig. 15. The PE-101-C dynamotor as operated with a 12 volt primary supply.

In actual practice, if the auxiliary battery is connected into the system with fairly long cables (as would be the case if the battery is mounted in the rear of the car) the cables will introduce enough resistance into the circuit to throw almost all the starting load of the car starter onto the original car battery which is connected to the starting motor by very short, heavy leads. Thus the starter current does not flow through the contacts of *RY2*.

It is suggested that the 325-volt tap be used to run the modulator and oscillator section of the transmitter and the 600-volt tap be used on the final amplifier stage.

PE-101C CONVERSION FOR 6-VOLT OPERATION

The PE-101C actually consists of two separate 12 volt d.c. dynamotors, with their respective commutators located at each end of the unit. The input commutators are located toward the outside, while those associated with the high voltage are nearer the center of the dynamotor. There are also some slip rings for a.c. output which have no value in amateur applications. The dynamotors have both series and shunt field coils, that is, they form a compound wound machine. The windings of the armatures are connected in a *simplex lap winding*, illustrated in *Figure 17*. In this type of winding a coil will start at commutator bar #1 and end up on bar #2. The next coil will start on bar #2 and end up on bar #3, etc., until the coils have gone all the way around the commutator and have returned to bar #1. This places two wires on each commutator bar, one above the other in the soldering slot.

Any d.c. machine may be reconnected to operate on one-half of its original voltage by changing the commutator connections from the simplex winding of *Figure 17* to a *multiplex winding*, such as shown in *Figure 18*. If this is done, the PE-101C dynamotor will deliver substantially the same output voltages on 6 volts that it was designed to do on 12 volts. In this multiplex arangement there is a coil between commutator bars #1 and #3, between #2 and #4, #3 and #5, #4 and #6, etc., until the coils reach bar #1 again. The original #1-#2 connection must now become a #1-#3 connection.

Figure 18 shows that the even-numbered bars are connected *together by* their coils, and the odd-numbered bars are connected *together through* their coils, each being separated from the other. Whereas the simplex winding has all coils in series in one circuit, the multiplex winding has half of the coils in series in each of two circuits. The change from simplex to multiplex is made by removing the proper end of each coil and moving it one bar ahead of its original place. This change must be made on each primary commutator circuit.

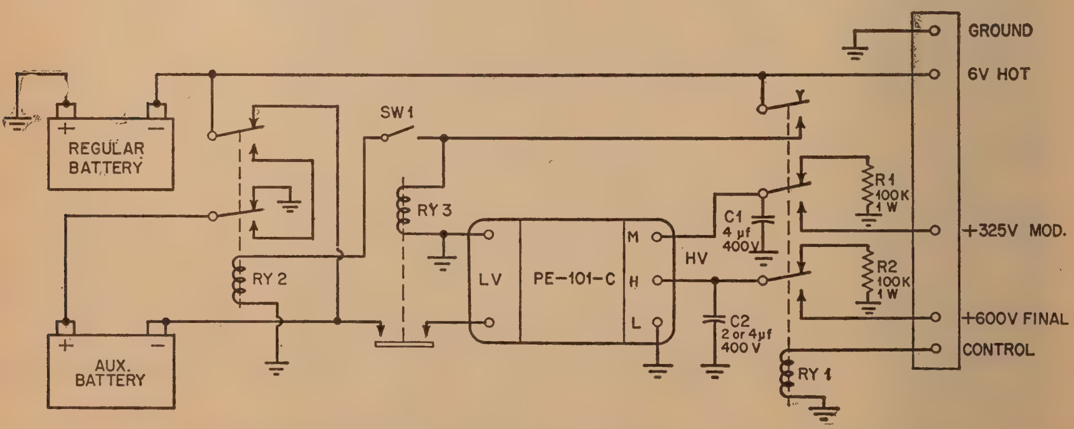


Fig. 16. This is the control circuit to be used for 6-volt automotive system and a separate battery to obtain 12 volts.

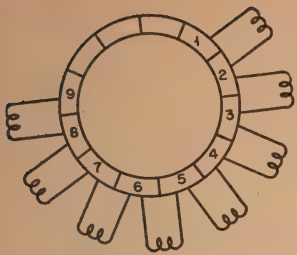


Fig. 17. Simplex lap winding.

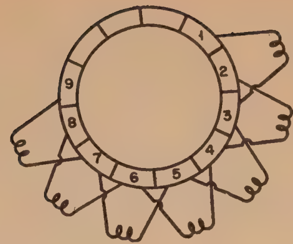


Fig. 18. Multiplex winding.

COMMUTATOR CHANGES

From here on, reference to motor #1 (*Figure 19*) will indicate the low voltage commutator that is located on the end of the shaft containing the two a.c. slip rings. Motor #2 is at the opposite end of the shaft.

Step 1. Remove all brushes at both ends of the unit. Be sure to tag them so that they can be replaced in their original holders. Mark them so that you will know which side is up when you wish to replace them.

Step 2. Disconnect all wires to the brush-holders at the motor #1 end.

Step 3. Remove the two long bolts, holding the dynamotor heads in place, and remove the end from which the brush-holder wires were disconnected, leaving the other head in place. If the armature bearing sticks to one head, tap it loose with a small block of wood.

Step 4. Cut a "V" in the center of each of two pieces of 2x4 wood, about six inches long to hold the armature while working upon it. Using a sharp pocket knife, remove the insulation on motor #1 between the generator commutator and the motor commutator, exposing the wires. You will be able to expose the wires about ½-inch back, which is sufficient length with which to work. Use care not to cut into the wires.

Step 5. The exposed wires for motor #1 are the top wires. These are the ones to be moved. The lower, insulated wires are not to be touched. Using a thin, flat-bladed screwdriver or a small pocket knife placed under each wire, pry up and release the wire from its bar. Do not attempt to unsolder. Care should be taken to keep the tool up close to the commutator so that the wire does not break. A slow, easy pry does the job. Keep the wire near the bar from which it came so no question will arise as to its original place.

Step 6. Place the armature on the table with the motor #1 end (the one you have been working on) toward you. Move each top wire to the *right* (*away* from the bar to which the other end is connected) by one bar and tap it down into the solder slot with a small screwdriver. This is the basic step of conversion from a simplex to a multiplex winding. This step is repeated for each *top wire* around the commutator. With the use of a small soldering iron resolder the wires to the commutator bars using very little solder. Use plenty of heat to insure a good connection and make sure no commutator bars are shorted out by solder. Do not let the solder run down on the flat portion of the commutator where the brushes will hit it. You should now have continuity between every other bar through the coil, and no continuity between adjacent bars, as shown in *Figure 18*.

Step 7. Push the coil wires down as tightly as possible with the fingers, then tap them down with a small block of wood. Check the soldered connections to make sure that none have broken loose. Replace the original insulation by winding common string over the wires. Paint well with varnish. Clean the commutator well, and clean between the bars. Remove all copper dust, and make sure the commutator is smooth.

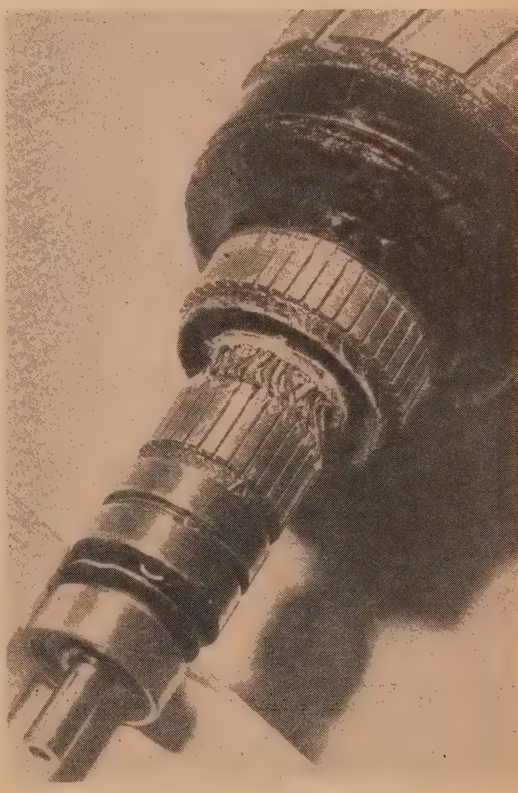


Fig. 19. The PE-101C armature showing the motor #1 end, and the a.c. slip rings. The large commutator is for the generator (output) section of the PE-101C.

Step 8. Motor #2 is converted next. In this conversion it is necessary to move the *bottom* wires and replace the top wires in their original places (*Figure 20*). This is necessary to keep the two motors "in step" with each other. After the top wires have been released from their respective bars, mark one wire and its bar with a drop of paint. Bend all wires in succession to a vertical position up against the generator commutator. Remove the thin insulation, using the same technique described previously. Pry up the bottom wires and (with motor #2 pointing *toward* you) move each of the *bottom* wires to the *left* (away from the other end of the coil). Tap the wires into their new position with a blade of a small screwdriver. Push down on the wires to make sure that they are down as far as they will go. Do not solder at this time. Replace the insulation with a single layer of cambric cloth, or other good, flexible material. Replace the top wires in their original positions. Solder all connections with a hot iron. Clean the connections and commutator, and reassemble the dynamotor.

Step 9. Try running each motor separately on 6 volts by replacing one set of brushes at a time, to see if both motors are running at top speed. This is indicated by a high pitched whine. The output voltage of each generator should be well over 500 volts. If one or both motors are running slow it is probably due to the brushes not seating properly. Be sure the commutator is clean and smooth. To seat the

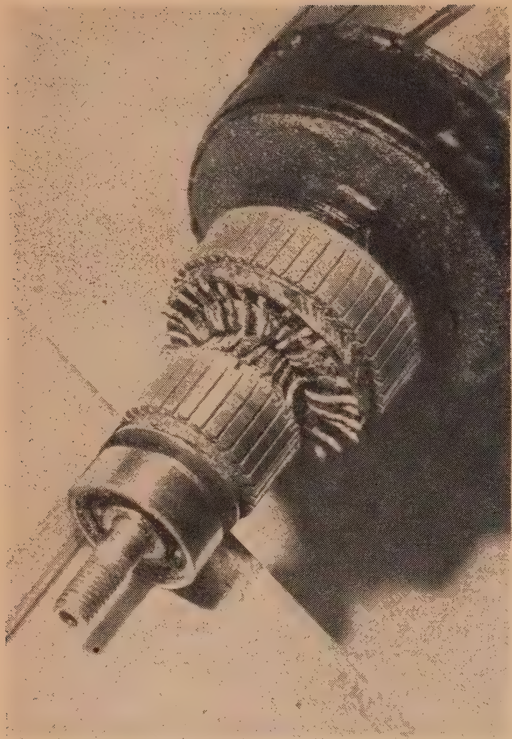


Fig. 20. The PE-101C armature showing the motor #2 end.

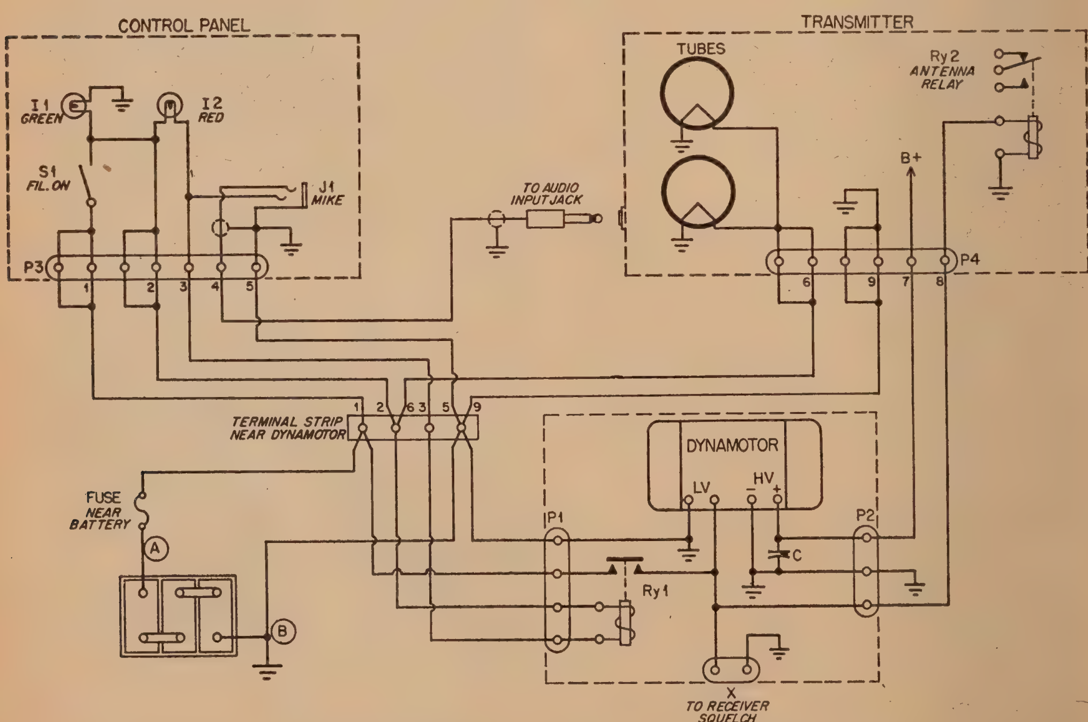


Fig. 21. Wiring schematic of a simple control panel circuit for mobile use.

brushes, wrap a strip of 0000 sandpaper around the commutator with the sandy side out. Put the brushes in the proper holders and turn the armature by hand several times in the *same* direction of rotation noticed when the unit is operating.

Dynamotor Output

After the conversion described above, the dynamotor will deliver the following simultaneous outputs:

550 volts at 150 ma.
275 volts at 125 ma.

Other 12-volt dynamotors can be modified from simplex to a multiplex winding by the above method. In like fashion, 24-volt dynamotors may be converted for 12-volt operation.

PE-101C Conversion for 300 Volt Supply

As seen in *Figure 13,* the 600 volt secondary winding of the PE-101-C consists of two high voltage windings in series, internally conected to each other by a jumper. These windings are nearly identical, but apparently not exactly so. The brushes for one winding are at one end of the armature and the brushes for the other high voltage winding are at the opposite end. The negative of one brush (terminal 1) is mounted integrally with the dynamotor frame, hence must always be grounded unless the dynamotor is insulated from the frame of the car. The positive brush of this winding (terminal 2) is jumpered to the negative brush of the second high voltage winding (terminal 3). If the jumper between terminals 2 and 3 is removed, and terminal 3 grounded, the following voltages and currents are delivered by the PE-101C.

Terminal 2 to ground: 315 volts at 150 ma.
Terminal 4 to ground: 340 volts at 150 ma.

Because of the voltage difference, no attempt should be made to parallel the outputs. Rather, one winding may be used to power the audio section of the transmitter, and the other winding may be employed to power the r-f section of the transmitter.

Control Circuits

The design of mobile transmitting equipment must follow a slightly different pattern than that of the usual fixed location equipment. Unless the mobile set is mounted directly in front of the operator (a difficult thing to do in an auto) some sort of remote control arrangement must be used, with the transmitter located in a more physically acceptable spot. The transmitter may be located in the trunk, on the engine firewall, in the engine compartment, or even in the glove compartment. The exact location will depend upon the size of the equipment and the tolerance of the other users of the car.

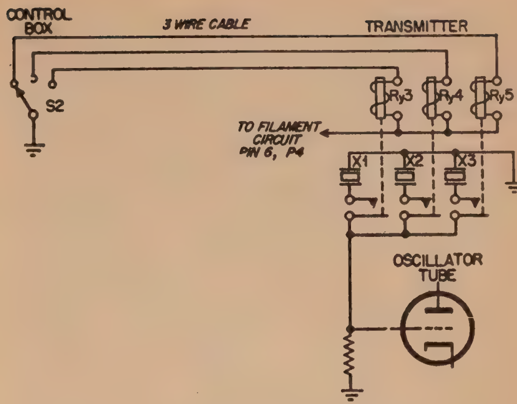


Fig. 22. This control circuit permits remote crystal selection.

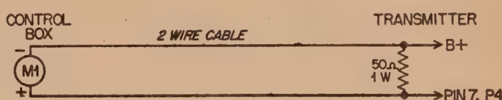


Fig. 23. There should be some method of observing the dynamotor secondary current drain. This idea can be added to the control circuit shown in Figure 21.

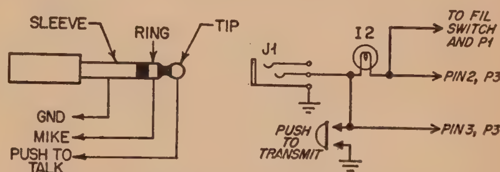


Fig. 24. Occasionally it is necessary to put the carrier on the air for a few seconds without modulation. The push-to-talk button shown in the right-hand schematic is useful.

The use of a remote control panel located near the operator will allow correct operation of the equipment when it is located at a distance from the operator. *Figure 21* illustrates a simple control panel for a typical mobile installation. Heavy wires *A* and *B* are the primary power leads and run directly from the battery to the dynamotor (or vibrator supply) broken only by a protecting fuse and control relay. If the transmitting equipment and dynamotor are located in the trunk compartment of the car, these leads may be run under the frame of the car, securely taped to a frame girder along the way. They are brought into the trunk compartment by means of a small hole drilled in the floor of the compartment. These leads carry considerable current and should be made of heavy wire. They should be well insulated from the car frame and from each other. Care should be taken to see that they do not chafe against sharp edges of the car frame.

The protective fuse should be located near

the battery. For current drains of 30 amperes or less, an ordinary house fuse mounted in a porcelain socket will work well. It should be in series with the ungrounded battery lead.

The control box is connected to the dynamotor by *leads 1, 2, 3, 4,* and *5*. *Leads 1* and *2* carry filament current of the transmitter and the current drawn by relay coil *Ry1*. This will usually amount to several amperes, so a suitable choice of wire should be made. *Lead 3* carries only relay coil current, so it may be made of No. 18 insulated wire. *Lead 4* is the microphone lead and must be made of shielded wire. The shield should be tightly woven and securely grounded to the car at both ends. *Lead 5* is the control box ground return lead.

Four leads run from the dynamotor to the transmitter, numbers *6, 7, 8* and *9*. *Leads 6* and *9* are filament leads and should be made of sufficiently heavy wire to carry the required load without appreciable voltage drop. *Leads 7* and *8* carry relatively small current and may be made of No. 18 insulated wire. *Lead 9* is the ground return wire. All leads to the control box should pass through a suitable plug and socket so that the control box or the cables may be readily removable for servicing or circuit changes. The plug may be mounted on the back of the control box. Two adjacent pins of the plug should be paralleled to carry the current flowing in *leads 1* and *2*.

The control panel contains a "Filament ON" switch and pilot lamp. When this switch is turned on the filament circuit is closed and both the tubes and the filament circuit pilot lamp are energized. The pilot lamp should be green in color, to signify that the low potential circuits are connected. At the same time, one side of relay coil *Ry1* is connected to the "hot" 6 volt lead. When it is desired to put the transmitter on the air, *lead 3* is connected to *lead 5* (ground) by means of a "press-to-talk" microphone, through the jack circuit on the control box. When *lead 3* is grounded the red "Transmit" light goes on, the opposite side of relay coil *Ry1* is grounded and relay *Ry1* closes. The dynamotor starts, and in the transmitter, antenna relay *Ry2* is energized, disconnecting the antenna from the receiver and applying it to the transmitter. An additional lead may be taken off at point *X* to energize the squelch relay located in the receiver. (See *Chapter 3*.)

Elaborating upon this basic design, additional control equipment and circuits may be added to

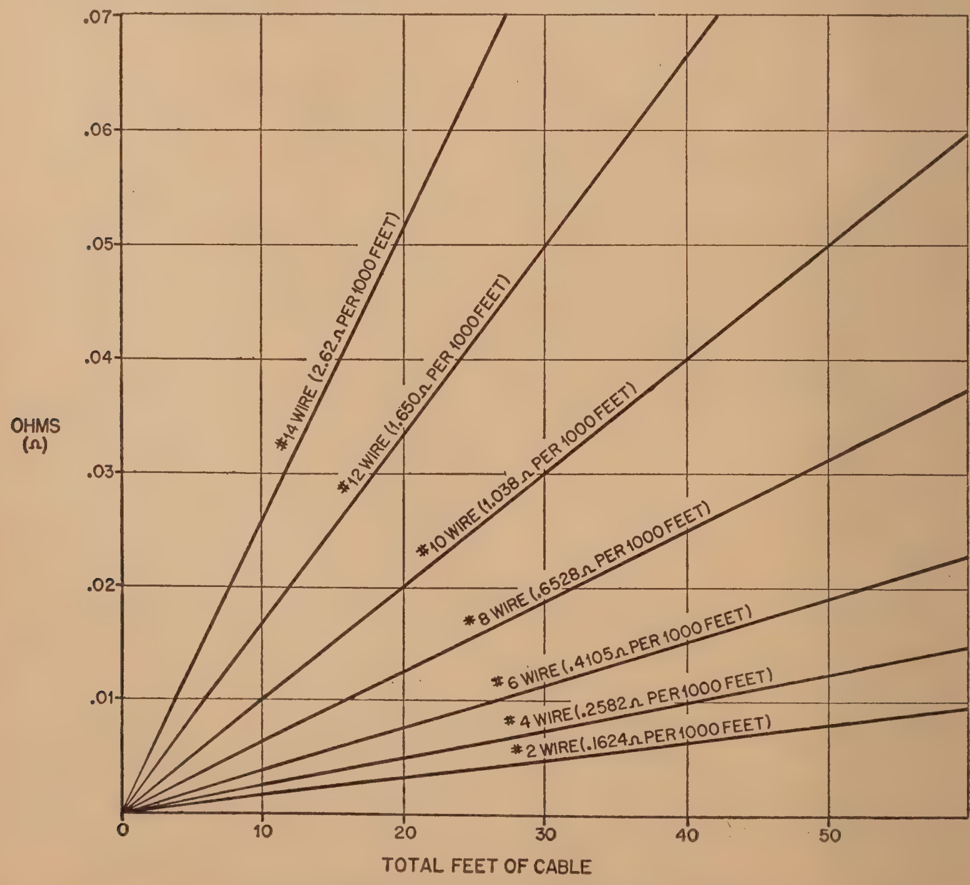


Fig. 25. Resistance values for various B&S wire sizes.

the basic control box. *Figure 22* illustrates a frequency shifting switch that allows the selection of several crystals. *Figure 23* shows the addition of a milliammeter to read the dynamotor secondary current drain. An additional push button type switch may be added between *leads 3* and *5* as a separate "Transmit" switch for use when the microphone circuit is not required. The standard push-to-talk microphone connections are shown in *Figure 24*.

CONTROL CIRCUIT COMPONENTS

The choice of components for high amperage control circuits is very important. Many times, the eager mobile enthusiast has thrown the control switch to start the dynamotor in his new mobile installation, only to find his 6-volt battery supply has dwindled to 3-volts at the dynamotor terminals. The d-c resistance of all control circuit components should be carefully examined and only those components with the lowest internal resistance should be chosen. For example, when a current of 50 amperes flows through a circuit containing a line resistance of only 0.06 ohm, a drop of 3 volts will occur in the line.

Wire

Figure 25 illustrates the resistance values of various lengths of standard gage copper wires. If the total lead length and wire size are known, the resistance of the wire may easily be found.

Plugs and Switches

The resistance of plugs and switches cannot be graphed in the above manner as the resistance of various plugs and switches varies widely, even among the same models made by the same manufacturer. It may be stated, however, that the greater the friction that exists between the two contacting parts, the lower will be the contact resistance. The following table gives some representative contact resistances of certain types of plugs and switches as measured on a Kelvin bridge:

Item	*Contact Resistance*
Jones plug & socket (P-2408)	0.003 ohm
5 prong tube socket & plug	0.05 ohm
Small 3 ampere toggle switch (SPST)	0.01 ohm
Large heavy duty toggle switch (C-H No. ST52-N)	0.003 ohm
"Unimax" snap switch	0.005 ohm

The contact resistance of the tube socket and matching plug varied widely depending upon the frictional fit of the prongs of the plug in the socket. The resistance of the 3 ampere toggle switch increased sharply after a few hours use breaking a current of 10 amperes. This was probably due to oxidation of the contacts.

The plugs and switches designed for heavy currents had sufficiently low resistance to be completely reliable in heavy current circuits.

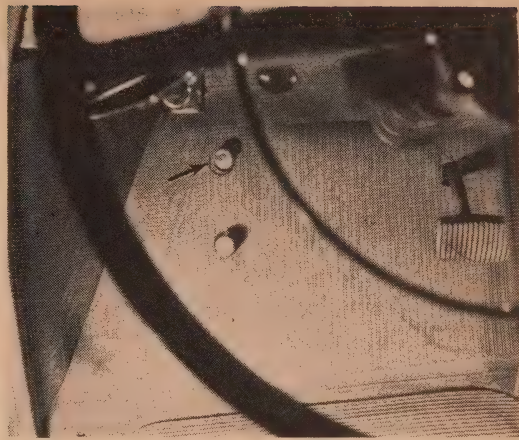


Fig. 26. Mounting of the foot-operated switch (headlight beam control type) to serve as a transmitter off-on switch at W5CLP.

Relays

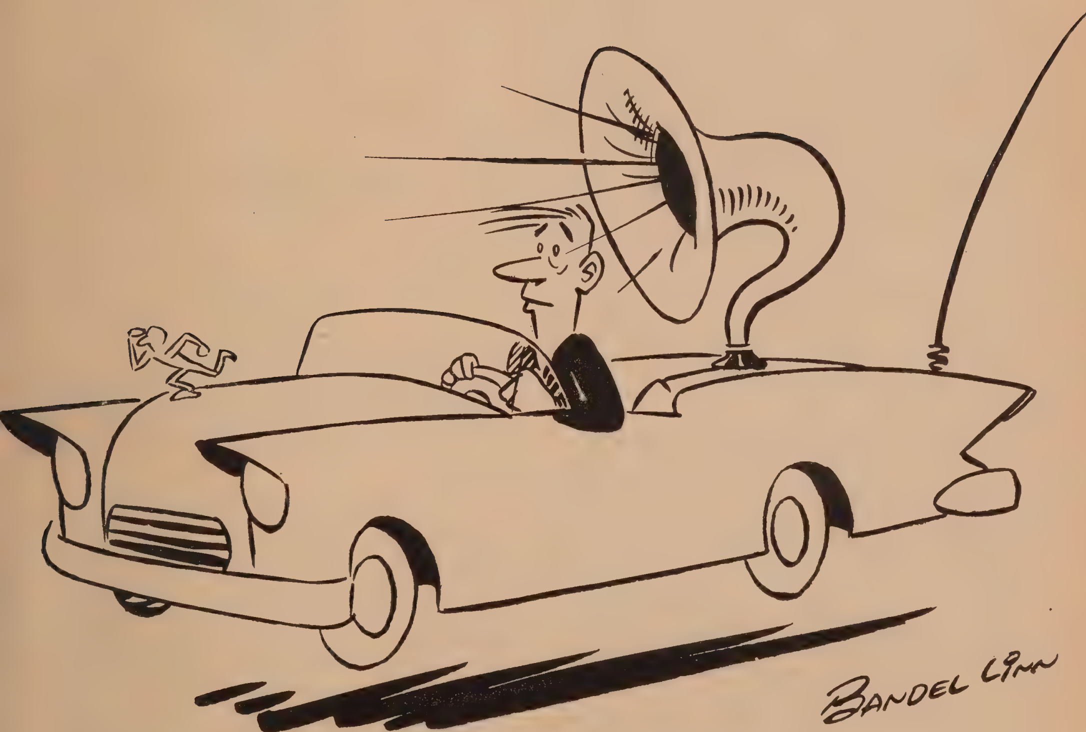
Relay contact resistance is a highly variable factor, more so than that of the plugs and switches. In general, a good relay for mobile service should have large, self-wiping contacts, a heavy return spring and a coil that draws at least two watts at 6-volts. The heavy duty coil will insure good contact pressure and a low resistance contact. It is important to keep the relay contacts clean, especially in industrial areas where a silver sulphide compound can easily form on the contact surfaces and increase the contact resistance many times.

A heavy-duty relay that is easily obtainable is the horn relay used in all makes of cars. It is stocked by all distributors and may be purchased for under two dollars. It is well suited for making and breaking heavy currents.

A step switch similar to that normally used for lowering the headlight beam in an automobile makes an ideal switch to turn the transmitter on and off. The switch may be mounted about six inches above the headlight switch so that the transmitter may be activated with a tap of the foot *(Figure 26)*.

Chapter Three

Mobile Receivers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Methods of Reception

To receive short wave signals in an automobile it is necessary to either extend the range of the usual automobile radio receiver, or to install an entirely different receiver which is capable of covering the amateur bands to be used. There are advantages and drawbacks to each idea. Let us examine both approaches and see their merits and drawbacks.

By far the most popular method of receiving amateur signals in mobile work is the use of a converter in conjunction with the car broadcast receiver. The car receiver serves as an i-f strip, second detector, audio amplifier and power supply.

Two different types of converters are in general use. The first and simplest type is the fixed tuned converter.

The Fixed tuned converter

A typical block diagram of a fixed tuned converter is shown in *Figure 1*. In the upper drawing a 28.5 Mc. signal is received and heterodyned against a fixed frequency oscillator operating on 30 Mc. This oscillator is usually crystal controlled for maximum stability. The output circuit of the detector is so tuned as to pick out the difference frequency created by the mixing action of the detector. This difference frequency is 1500 kilocycles, which may be tuned in on the car receiver. When a signal of 29.5 Mc. is received, as shown in the lower drawing, it is heterodyned against the 30 Mc. oscillator to produce a difference frequency of 500 kilocycles. Thus the frequency range of 28.5 Mc. to 29.5 Mc. may be covered by tuning the car receiver from 1500 kc to 500 kc.

Advantages of Fixed-tuned converter

1—The conversion oscillator may be crystal controlled for maximum frequency stability.
2—The converter has no tuning controls and may be located out of sight in the automobile.
3—The converter may be considerably smaller in size than the usual tunable converter.
4—The tuning dial of the broadcast receiver is used for amateur band coverage.

Disadvantages of Fixed-tuned converter

1—The input circuit of the converter must be broadbanded for coverage of a complete amateur band. Image rejection is degraded below maximum performance.
2—The i-f output circuit must be broadbanded to cover 500-1500 kc. This usually means an untuned output circuit, leaving only the selectivity of the broadcast set to cope with any spurious responses.
3—There is possibility of "ride through" of local broadcast stations as the broadcast receiver is tuned across the dial.
4—The dial mechanism of the broadcast receiver may not be precise enough for accurate logging and tuning of high frequencies.
5—Image rejection ability becomes poorer as the broadcast receiver is tuned lower in frequency. The image frequency is continually changing and approaching the signal frequency.

In spite of these disadvantages, the fixed-tuned converter is very popular, especially for 28 Mc. operation where the stability of the fixed oscillator is a great advantage.

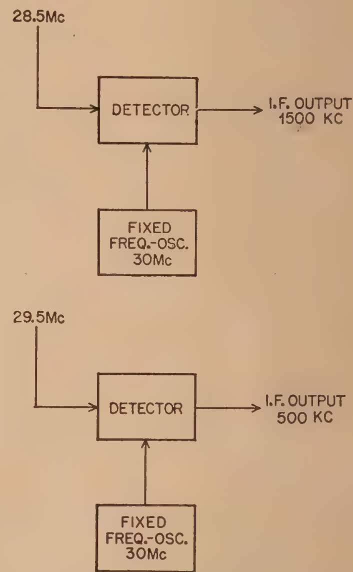


Fig. 1. Operating principle of a fixed-tuned converter. Note that the oscillator is not tunable.

The Tunable Converter

The most universally used converter for amateur mobile reception is the tunable converter. (*Figure 2*). Here, in contrast to the fixed tuned converter, the i-f output is constant. A frequency of 1500 kc is used, since this frequency affords the greatest image rejection obtainable in the broadcast range. To obtain the correct tuning range the high frequency oscillator is variable, tuning over the same number of kilocycles as does the detector input circuit. However, the oscillator tuning range is removed from the detector tuning range by an amount equal to the fixed intermediate frequency. Thus, when the received signal is on 28.5 Mc., the oscillator is on 30 Mc., producing a "difference-frequency" of 1500 kc. When the received signal is on 29.5 Mc., the oscillator must be on 31 Mc., again producing a

"difference-frequency" of 1500 kc. This difference frequency of 1500 kc may be "spotted" on the car receiver as a fixed signal.

Advantages of Tunable Converter

1—The detector and r-f stage of the converter may be ganged-tuned. A narrow-band selective r-f stage can be used for highest image rejection and greatly reduced cross-talk.
2—The broadcast receiver is fixed tuned to 1500 kc, for best image rejection. The tuning dial of the broadcast receiver is not used.
3—The i-f output circuit of the converter may be peaked at 1500 kc, reducing spurious responses in the i-f system.
4—The converter may easily contain band-switching, whereas the fixed tuned converter is usually a one band device.
5—Danger of broadcast "ride through" is considerably reduced as the intermediate frequency may be shifted slightly from 1500 kc to avoid a local station.

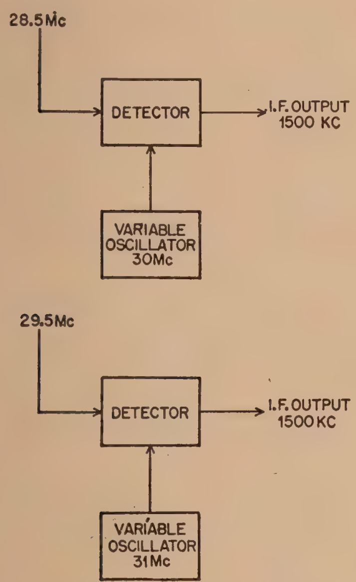


Fig. 2. Operating principle of a tunable converter. Note that in contrast to Fig. 1 the first oscillator is tuned and the intermediate frequency remains constant.

Disadvantages of tunable converter

1—The tunable oscillator is relatively unstable compared to a fixed-tuned crystal oscillator.
2—Since the converter must be tuned, it must be located near the operator in an accessible part of the car.
3—The physical size of the tunable converter is usually larger than that of the untuned converter.

The tunable converter is the most popular variety for general amateur use. The oscillator instability may be largely overcome by proper oscillator design and the use of voltage regulator tubes on the plate supply of the oscillator.

Locating the Converter or Receiver in the Automobile

The location of the converter or receiver in the automobile is of the utmost importance. It should be easily accessible from the driving position, yet not block the entrance or exit nor inconvenience the driver or passengers. The three most popular mounting places for the receiving equipment are:

1 — Attached to the Steering Column.

A suitable clamp can be made (*Figure 3*) of soft dural or sheet iron that will encircle the body of the converter and grasp the steering column. The face of the converter will mount about 5 inches behind and to the left of the steering wheel. The converter is tuned with the left hand. By loosening the clamp the converter can easily be removed from the automobile for testing or servicing.

2 — Mounted beneath the instrument panel.

In many cars the converter may be mounted under the instrument panel (*Figures 4 and 5*). To permit easy removal of the converter it is suggested that it be held in place by a metal strap encircling the body of the converter.

3 — Atop the instrument panel.

The converter may be placed atop the instrument panel to the left of the steering wheel. Where it is not desired to disfigure the car, the converter may be mounted in place by a large rubber suction cup, whose lip has been coated with shellac (*Figure 6*).

Other less frequently used positions are: In the glove compartment, or below the glove compartment against the fire wall.

Adapting the Car Receiver for Use with a Converter

For best operation of the converter it is necessary to add a noise limiter, and at the same time to make some minor alterations to the car receiver. The installation of a noise limiter is covered in Chapter 4. The minor alterations are:

1 — Power connections.

The power leads for testing the converter may be temporarily "haywired" to the broadcast receiver. Afterwards, it is best to install a permanent octal tube socket or *Jones Socket* on the broadcast receiver through which the plate and filament power for the converter may be obtained, and through which a muting system can be applied to the broadcast receiver to silence it during transmissions. The schematic diagram, *Figure 7*, shows the necessary connections to the broadcast receiver. An octal socket is mounted on a convenient space on the wall of the car receiver. A shielded cable from this plug will carry the power to the con-

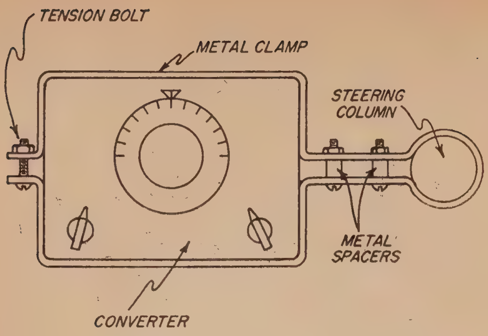


Fig. 3. A metal clamp may be easily fabricated to encircle the converter and strap it to the steering column.

verter. *Pins 1 and 2* of the socket are grounded to the chassis of the car receiver. *Pin 7* is connected to the "hot" heater line. The filaments of the converter will then be turned on at the same time the broadcast receiver is turned on. A small 6-volt d-c relay, *R*, with normally closed contacts is mounted in the car receiver and is so connected as to open the B-plus to both the converter and the last audio stage of the car receiver when *Pin 5* of the octal plug is grounded.

All leads in the car receiver to the octal socket are bypassed by .001 $\mu fd.$ ceramic disc condensers mounted on the socket. The cable leads from *pins 3, 5 and 7* should be made of shielded wire. The shields should be grounded to *pins 1 and 2* of the octal plug.

2 — Alignment of the Automobile Receiver.

After the converter is connected and is operating, the broadcast receiver should be trimmed for maximum sensitivity in the vicinity of 1500 kilocycles. On most car receivers an antenna trimmer control is mounted near the antenna input receptacle.

If the receiver has a mechanical push button system, one button may be set to the output i-f of the converter. Those receivers having electrical push buttons (wherin the push button substitutes a fixed tuned preset circuit for the manual tuning circuit) should be tuned manually to the i-f, since such sets usually suffer a severe drop in gain when the fixed tuned channels are used. This happens because fewer tuned circuits are used in the fixed tuned channels than in the manual tuning channel.

Some of the newer cars are equipped with a signal seeking receiver which tunes progressively to each succeeding strong signal across the dial. In this case a switch should be installed on the side of the receiver to disconnect the signal seeking mechanism while the converter is in use.

3 — Connecting the Converter to the Receiver.

The output lead from the converter to the input receptacle of the car receiver should be made of low capacity coaxial cable especially designed for automobile installations. The section that comes with the car receiver may be used if it is cut as short as possible. Special low capacity cable may be purchased in 18 inch lengths, (*Ward No. C-9*) for use in this application. Ordinary coaxial cable or shielded wire has too much distributed capacity to give the best possible results.

As a final step, the input and output circuits of the converter should be peaked to match the individual installation and antenna. An external signal should be used for this operation.

Mobile Receivers: Summary

The converter/broadcast receiver combination is far from the ultimate in regards to selectivity, sensitivity and flexibility. The overall performance of the combination is limited by the capabilities of the broadcast receiver, which in some instances is not designed to a high order of selectivity or sensitivity. The addition of an "outboard" 1500 kc i-f stage will help

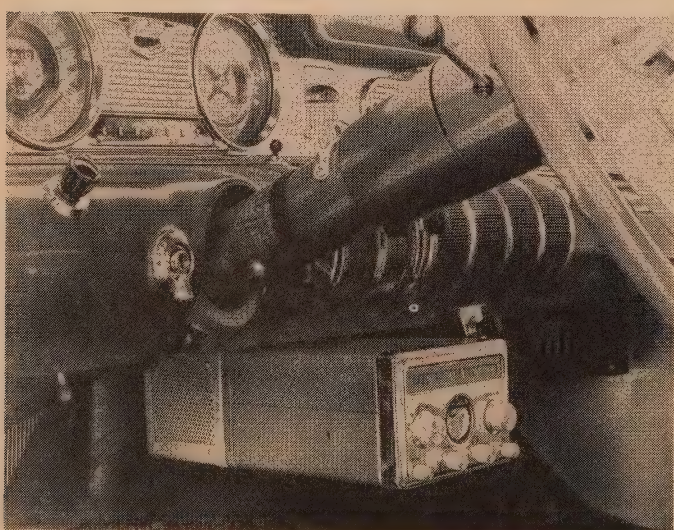


Fig. 4. The converter or receiver may be mounted beneath the dash of the car, either to the right or left of the steering column. The unit may be tuned with one hand while the car is in motion. Shown here is the Gonset G-66 receiver mounted in a Buick "Century."

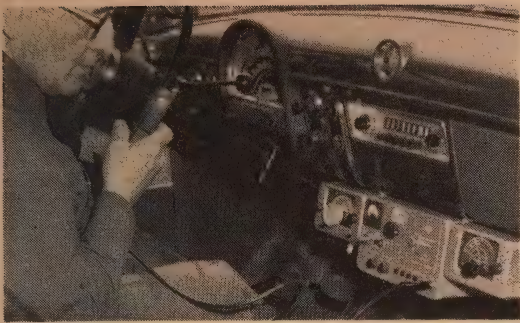


Fig. 5. The complete station may be mounted beneath the automobile radio, as shown in this installation.

somewhat, but will also add another piece of equipment to cram into the automobile.

Some of the more serious mobile operators employ complete mobile receivers incorporating all the best features of standard communications receivers. This provides a mobile receiver of the highest order. *Figure 8* illustrates in block diagram a typical high quality mobile receiver. This receiver has a band-switching front end, tuning amateur bands from 3.5-30 Mc. It has a tunable r-f stage, a voltage regulated h-f oscillator, dual conversion (1500 kc and 262 kc) for high selectivity, two i-f stages, AVC and noise limiter, two audio stages and a self contained speaker. It is entirely comparable in performance with a high grade home communications receiver. Several commercial receivers of this type are available on the market.

The choice between a converter and a complete mobile receiver will depend largely upon whether mobile operations are approached as a part time hobby, or whether the mobile station installation is the primary source of amateur operation. The complete receiver is the best solution, but also the most complicated and expensive.

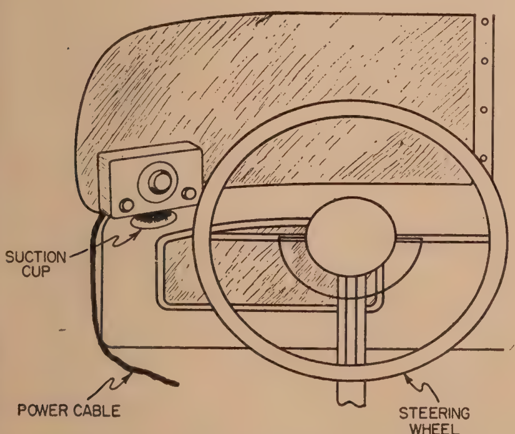


Fig. 6. If it is vitally necessary not to disfigure the dashboard or steering wheel, a large suction cup could be mounted on the bottom of the converter. The power cables should plug into the broadcast receiver.

a Fixed-tuned Converter for 80-40 Meter Operation

Shown in *Figures 9, 10 and 11* is a simple one tube fixed-tuned converter, suitable for operation on the 80 and 40 meter phone bands. It is compact in size and is crystal controlled, all tuning being done with the automobile receiver.

The circuit of the converter is shown in *Figure 10*. A single 6BA7 (or 12BA7) tube is used as a combined mixer and conversion oscillator. The 80 or 40 meter signal is coupled to the transmitting whip through a high-Q tank circuit, *L2-C1*. The value of *L2* is chosen so that *C1* tunes to 40 meters when it is set near minimum capacity, and to 80 meters when it is set near maximum capacity. Thus no coil changing or switching circuits are necessary to change from reception on one band to the other. The input signal is applied to grid #3 of the 6BA7 tube.

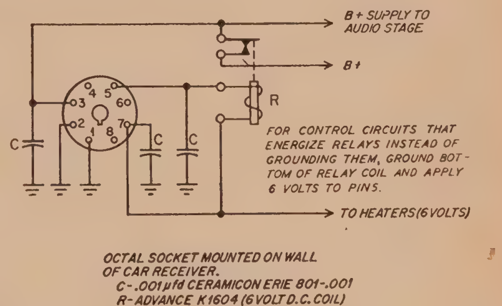


Fig. 7. An octal (or Jones) socket should be permanently mounted on the automobile broadcast receiver to supply power to the converter.

A Pierce oscillator circuit is formed between the #1 grid of the 6BA7 and the numbers 2 and 4 grids, which are paralleled within the tube. The #2 and #4 grids serve as the "plate" of the Pierce oscillator, and the #1 grid serves as the oscillator grid. The tuned circuit of the oscillator is a quartz crystal, placed between the grid and "plate" electrodes of the tube. To supply sufficient feedback to maintain oscillation, the "plate" of the oscillator is bypassed to the cathode circuit by means of a small mica condenser, *C2*. Mixing action takes place between the beating oscillator and the input

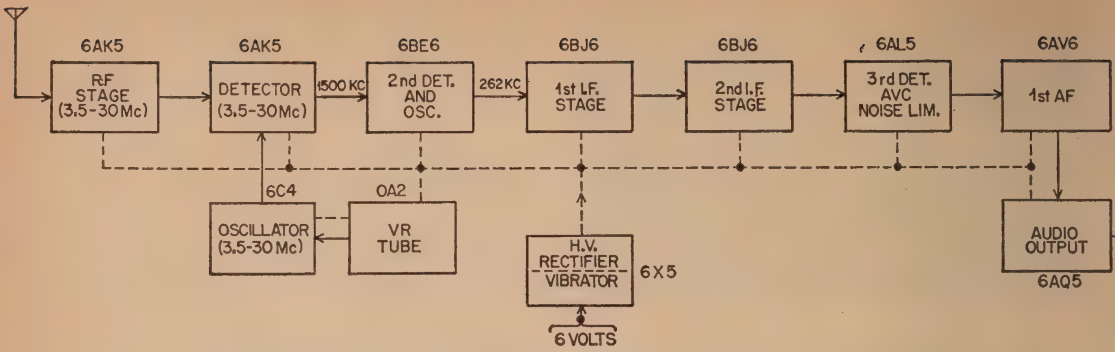


Fig. 8. Block diagram of the present-day ultimate in mobile receiver design.

signal in the internal electron stream of the tube.

An untuned output circuit is used in this converter, the inherent image rejection of the automobile receiver at the (approximately) 1500 kc first intermediate frequency being sufficient to reject images. In addition, the extremely high-Q of the usual 80 or 40 meter transmitting whip is sufficient to afford excellent image rejection.

An "In-Out" switch is utilized to place the converter in or out of service. In the "Out" position, the automobile receiver is disconnected from the converter and connected to the standard automobile antenna. Since the converter draws a minimum amount of power, it is left connected in the circuit at all times. If desired, a double-pole double-throw switch may be substituted for the SPDT switch in the converter, the extra set of contacts being employed to break the plate voltage to the converter when the switch is thrown to the "Out" position. It is advisable to arrange the wiring of the converter so that the residual capacity between the wires of this switch is at a minimum to avoid external broadcast pickup by the automobile receiver when the converter is in use. Good clearance between the wires leading to the "In" and "Out" terminals of the switch will do the trick.

The region into which the 80 and 40 meter bands will fall on the dial of the automobile receiver is determined by the frequency of the conversion crystal used in the converter. For example, a 3.0 Mc. crystal will position the 80 meter phone band between 800 and 1000 kc on the car receiver dial. A 2.5 Mc crystal will place the phone band between 600 and 800 kc. The formula for determining just where the band will fall on the car receiver dial is simple: Band edge frequency minus crystal frequency equals broadcast band dial frequency.

For 40 meter operation, a crystal below the 7 Mc. region is used. A 6.2 Mc. crystal, for example will place the 7200-7300 kc phone band between 1000 and 1100 kc on the car receiver dial. Two crystals are thus required; one for 80 meter operation, and one for 40 meter operation. It is obvious that the particular choice of crystal frequency will depend to some extent in which portion of the broadcast band strong local signals appear, since "ride-through" of a very strong local b-c station is a possibility in this simple converter.

Construction

Construction of this converter is not difficult. It is built in and upon a chassis-box measuring 6" x 3½" x 2" (*L.M.B. Co.*). If desired, a *Bud #CU-3006* box (5¼" x 3" x 2") may be substituted. Placement of most of the major components may be seen in *Figure 11*. Across the back lip of the box are mounted (from left to right) the converter antenna receptacle, the 6BA7 tube socket, the 7/16" hole for the power cord grommet, the converter output receptacle, the conversion crystal and the "In-Out" switch, followed by the b-c antenna receptacle.

On the "base" of the chassis box are mounted the phenolic terminal strip supporting *L1* and *L2*, the main tuning condenser, *C1*, a 5-point phenolic terminal strip supporting the screen and plate circuit resistors and the .01 μfd plate bypass condenser, and *C3*, the output circuit tuning condenser.

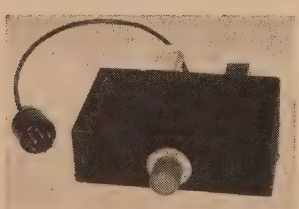
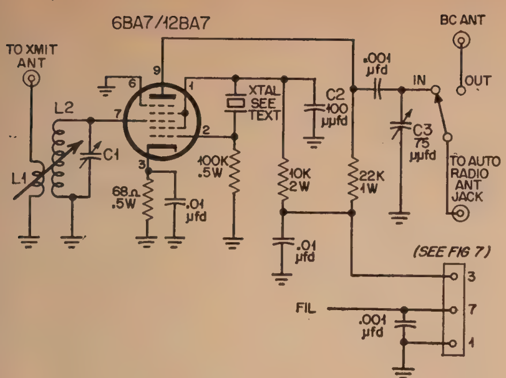


Fig. 9. The one-tube 80-40 meter converter is only two inches thick and may be easily mounted beneath the dashboard of your automobile. The r-f tuning control is centered on the front of the unit. The 6BA7 converter tube and conversion crystal project out the rear of the case. The "In-Out" switch is also mounted on the rear of the case.



C1—140 µµfd Bud C-954.
C2—100 µµfd (see text).
C3—75 µµfd mica padder. El Menco #582.
L1 — B&W Miniductor #3008. ⅝″ long, ⅝″ diam., 18 turns #20.
L2 — B&W Miniductor #3008. 1 11/16″ long, ⅝″ diam., 52 turns #20.

All .001 µfd condensers are Centralab DD-102 ceramic discs.
All .01 µfd condensers are Centralab DD-1032 ceramic discs.
Antenna jacks are ICA #2378.
Switch is Carling #S-60B or equivalent.

Fig. 10. 80-40 meter Single tube converter

The r-f tuning condenser is firmly mounted to the inside of the box by a 6-32 screw passing through the rear foot of the condenser, and by the 3/8″ collar-nut on the front bearing of the condenser. All components except *L1* and *L2* should be mounted before wiring is done.

Wiring

The wiring of this little converter is exceedingly simple. The plate and screen resistors, plus the .01 µfd ceramic plate bypass condenser are mounted on the 5 terminal phenolic tie-point strip before it is bolted to the chassis. One side of the .01 µfd condenser is soldered to the ground lug of the strip. *Pins 4 and 6* of the 6BA7 socket are grounded, and a .001 µfd ceramic condenser is connected between *pins 4 and 5*. A 100 µµfd mica condenser is connected between *pins 1 and 4* of the socket. A short lead connects *pin 1* to the 10,000 ohm screen resistor on the plate tie-point strip. The cathode resistor and by-pass condenser connect between *pin 3* of the socket and the nearest grounding point. The .001 µfd plate coupling condenser connects between the 22,000 ohm plate load resistor and one lug of *C3*.

When the preliminary wiring is completed, *L1* and *L2* may be clipped from a section of B&W 3008 *Miniductor,* and *L2* is mounted on the two outside terminals of a 5 terminal phenolic tie-point strip. It is supported entirely by its leads. The ground end of *L2* is towards the front of the converter, a short jumper going between the tie-point supporting this end of *L2* and the center ground lug of the tie-point strip. All unused lugs on the strip are bent over to prevent them from touching *L2*.

One end of *L1* is grounded to the lug supporting the "front" end of *L2*, and the other end of *L1* attaches to a short length of #12 wire which is fastened at its opposite end to the converter antenna receptacle, mounted on the back lip of the chassis behind *L2*. If the leads to *L1* are made about 3/4″ long, *L1* may be moved about to adjust the degree of coupling between *L1* and *L2*.

After the coils have been wired in the circuit, all wiring should be checked, and the power cable and plug attached to the converter.

Converter Check-Out

The converter should now be installed in the car for an operational test. The switch should be in the "Out" position, and antenna and power connections made to the converter. The antenna trimmer on the automobile broadcast receiver should be tuned for best response at the center of the broadcast range that will be used by the converter. The converter function switch should now be thrown to the "In" position, and trimmer *C3* peaked for best short wave reception. The r-f tuning control *C1* may be peaked on a strong local signal on either 80 or 40 meters, and the coupling between *L1* and *L2* adjusted for best reception. When the correct point of coupling is found (it is not critical) *L1* may be held in place by a small strip of celluloid and an application of nail polish. Band-changing is accomplished by substituting conversion crystals and retuning *C1*. In all instances, it is mandatory that a loaded antenna tuned to the band in use be employed with this converter.

12 Volt Operation of the Fixed-tuned Converters

When it is desired to operate any of these

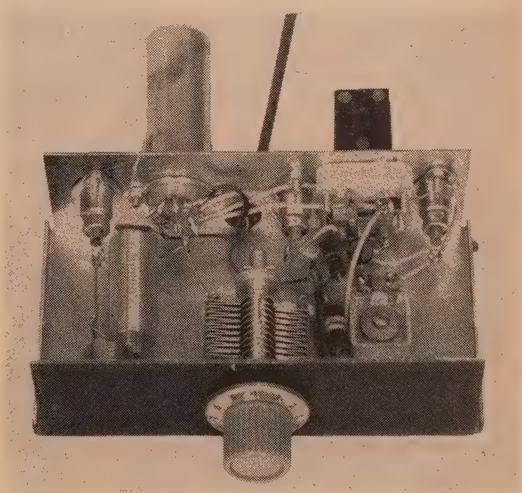
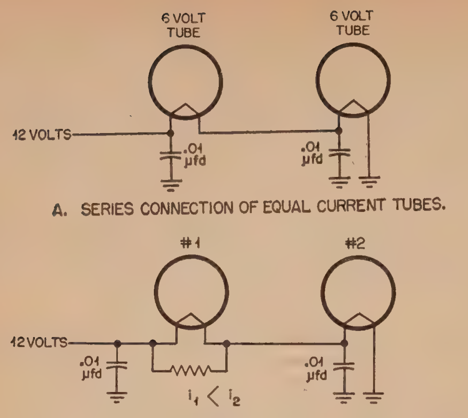


Fig. 11. Interior view of the single tube 80-40 meter converter. Coils L1 and L2 are mounted to the left of the r-f tuning control, C1. Directly to the right of C1 is the output alignment condenser, C3, mounted to the chassis base. It is adjustable from beneath the converter.



A. SERIES CONNECTION OF EQUAL CURRENT TUBES.

B. SERIES CONNECTION OF UNEQUAL CURRENT TUBES.

Fig. 12. Series Filament arrangements

simple converters from a 12-volt automobile system, the most simple solution is to substitute 12-volt filament tubes for the 6-volt tubes. Thus, in the converter just described, a 12BA7 would be employed in place of the 6BA7. In some instances there is no exact 12-volt equivalent for a particular 6-volt tube. The 6AK5 is such a case. Under these circumstances, it is necessary to place sufficient resistance in series with each 6-volt filament so that the tube will draw the proper current, even though it is working from a 12-volt supply. Two tubes having similar 6-volt filaments may be placed in series and operated from a 12-volt supply. Two 6AK5 tubes with their filaments in series will operate from 12 volts. A 6BA6 and a 6BE6 may be run with their filaments in series, since they both draw the same filament current (0.3 amperes) at 6.3 volts. In fact, any two 6-volt tubes that draw the same amount of filament current may be placed in series for 12-volt operation, as shown in *Figure 12A*. It can be seen that the filament circuit of one tube is 6 volts "above ground", and one pin of this tube should be bypassed to ground with a .01 µfd ceramic condenser.

The 6-volt tubes that draw different amounts of filament current may be connected in series across a 12-volt line if a suitable shunting resistor is placed across the tube having the lowest amperage filament, as shown in *Figure 12B*.

Variations of the Fixed-tuned Converter

Several interesting variations of the basic converter may be made. Illustrated in *Figures 13 and 14* are two simple circuits that perform in a highly efficient manner. The circuit of *Figure 13* is a converter for the 6-meter (50 Mc.) or 10-meter (28 Mc.) band, employing a single 12AT7 tube. It is built into a box much like the 6BA7 converter described previously.

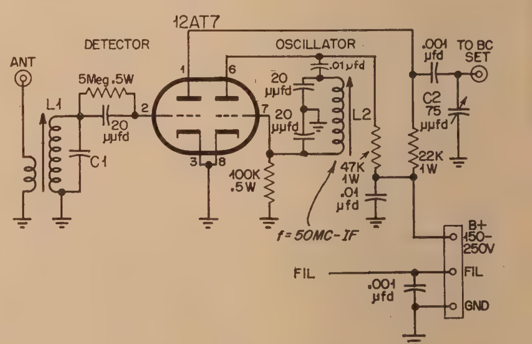
The first section of the 12AT7 is the conversion detector, having a slug-tuned grid circuit that is broadly resonant to 50 Mc. The second section of the 12AT7 is a self-excited oscillator, operating in the region just below 50 Mc. Tuning the broadcast receiver of the automobile from 500 kc to 1500 kc will cover a 1000 kc segment of the 50 Mc. band. Since most operation takes place in the lower 500 kc segment of the band, the oscillator section of the 12AT7 may be tuned to about 49.3 Mc. This will position 50 Mc. at 700 kc on the dial of the auto radio.

The two tuned circuits of this converter may be set to frequency with the aid of a grid-dip oscillator. Once the frequency of the oscillator coil has been set, the slug of the coil should be sealed with a drop of nail polish or Duco cement to prevent frequency instability caused by vibration of the slug within the coil form.

There is no danger of oscillation if stray coupling exists between coils *L1* and *L2*, so they may both be mounted within the converter box without the necessity of placing a shield between them. Silver mica condensers should be used across *L1* and *L2* for maximum circuit stability.

When completed, the converter may be tested by peaking it upon a local signal. The output circuit trimmer, *C2*, is adjusted in the same manner as the trimmer of the 6BA7 converter discussed in the previous section.

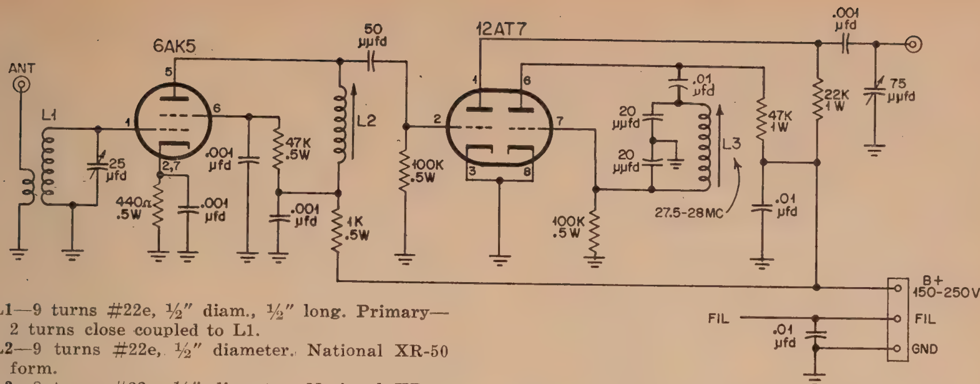
Shown in *Figure 14* is a two tube version of a 10 meter fixed-tuned converter. A 6AK5 r-f stage is added to the detector circuit for maximum sensitivity. The sensitivity of the 12AT7 detector alone is approximately 5 microvolts for a 6 db. signal-to-noise ratio which is ample to overcome car noises in most installations. In some instances, it is desired to have a sensitivity of less than 1 microvolt for a 6 db. signal-to-noise ratio. Such a ratio may easily



Six meters:
- C1—10 µµf.
- L1—6½ turns #30e, on Millen 69041 slug form. Primary—2 turns close coupled to L1.
- L2—8 turns #30e, on Millen 69041 slug form.

Ten meters:
- C1—20 µµf.
- L1—20 turns #22e on ⅜" CTC LS-3 slug form. Primary—2 turns close coupled to L1.
- L2—Same as L1.

Fig. 13. 6-10 meter single tube converter



L1—9 turns #22e, ½" diam., ½" long. Primary—2 turns close coupled to L1.
L2—9 turns #22e, ½" diameter. National XR-50 form.
L3—8 turns #22e, ½" diameter. National XR-50 form.
Adjust coils to frequency with grid dip oscillator.

Fig. 14. 10-11 meter two tube converter

be obtained by the 6AK5 r-f stage.

The sensitivity of the converter may be controlled by varying the value of the cathode bias resistor of the r-f stage. If sufficient shielding is used between the grid and plate circuits of the 6AK5 stage, the cathode resistor may be as low as 150 ohms. Residual coupling between *L1* and *L2* may make it necessary to increase the cathode resistor to 700 ohms to prevent the r-f stage from breaking into oscillation when *L1* and *L2* are both tuned to the same frequency.

The converter may be built in a 2"x3"x4" aluminum box, divided into two sections by a shield made of a piece of flashing copper fastened securely to the sides and top of the box. A small foot should be left on the shield so that when the bottom of the box is bolted in position the shield may be affixed to the bottom plate by means of a self-tapping sheet metal screw. This will insure that the shield is grounded on all four sides.

The section of the 12AT7 that serves as the h-f oscillator should be tuned to the low frequency side of the 28 Mc. band. 1000 kilocycles of the band may be covered on the dial of the automobile receiver. If it is desired to cover the lower 1000 kc of the 10 meter band, the slug of *L3* should be adjusted to tune the oscillator circuit to 27.5 Mc. The converter will then "tune" 28.0-29.0 Mc. If *L3* is adjusted to 28.2 Mc., the converter will then "tune" 28.7-29.7 Mc.

This circuit will perform in excellent fashion on the lower frequency bands. It is necessary to rewind *L1* and *L2* so that they resonate at the center of the frequency range to be covered. *L3* should resonate about 1-Mc. below the band in question when padded by the two series connected silver mica padding condensers. For each successively lower band, the capacity of each of these condensers should be increased by a factor of three.

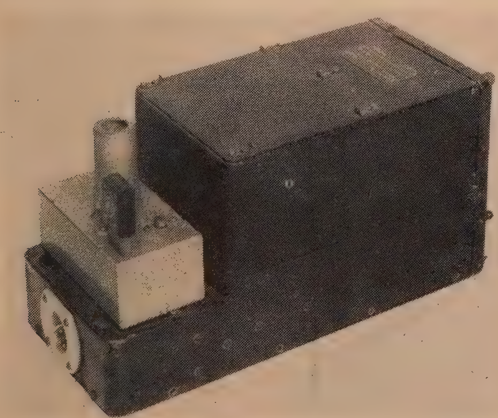


Fig. 15. A fixed tuned converter for a "Command Receiver."

a Fixed-Tuned Converter for the "Command" Receivers

Shown in *Figures 15, 16 and 17* is a simple one tube converter that is designed to be used with either the low frequency (BC-453A) or the broadcast band (BC-946) "Command" receiver. It is designed to mount in the dynamotor well of the receiver on a small metal chassis. The converter is crystal controlled, and all tuning is done with the main dial of the Command receiver. An installation such as this makes a compact, efficient mobile installation for even the smallest car. The price of the converter and the Command-set is comfortably lower than the cost of a converter that is comparable in performance.

Power for both the Command-set and the converter may be taken from the automobile receiver in the car. If there is none, a small vibrator power supply, such as shown in *Figure 18* may be constructed to power the combination.

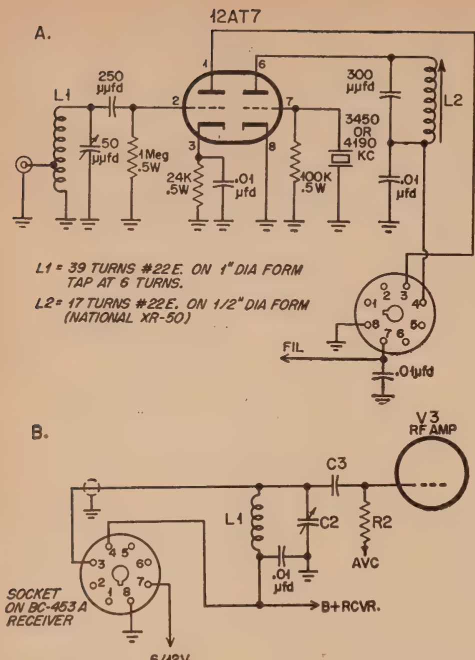


Fig. 16. A—Schematic of crystal converter. B—Modifications to "Command" Receiver.

The converter is designed for either 80 meter or 40 meter operation. When a BC-453A receiver is employed, the range of 3640 kc to 4000 kc may be covered on the 80 meter band if either a 3450 kc crystal or a 4190 kc crystal is used in the converter. The 3450 kc crystal is recommended, since the dial reading will increase with frequency in the normal manner. When the 4190 kc crystal is used, the dial will read "backwards", the 80 meter frequency increasing as the receiver is tuned lower in frequency. For 40 meter operation a crystal in the region of 6800-6950 kc should be used. If the BC-946 is used for the i-f system of this converter, a crystal between 2500 kc and 3000 kc should be used for 80 meter operation, and between 5800 kc and 6500 kc for 40 meter operation.

Converter Construction

The converter is constructed in and upon a small aluminum chassis-box measuring approximately 2"x1½"x4" (*Bud CU-2102*). The "top" of the box is bolted to the chassis of the Command receiver, and all components of the converter are mounted in the removable box section, as shown in *Figure 17*. The 12AT7 tube socket is centrally mounted on the U-shaped piece of aluminum, with the crystal socket and r-f tuning condenser to one side. The socket is oriented so that *pin #6* is next to the crystal socket. The oscillator coil, *L2*, is mounted on the chassis between the crystal socket and the tube socket. The small ceramic padding condenser is mounted across the terminals of the coil, and the 0.01 *μfd* bypass condenser is connected between the bottom lug of the coil and the grounded filament pin of the 12AT7 tube.

The grid input coil, *L1*, and the antenna input jack are mounted on the opposite end wall of the chassis. The four leads that connect the converter to the receiver terminate in an octal plug which connects to an octal socket that is mounted in the center of the dynamotor space. The socket hole is cut through both the receiver chassis and the section of the chassis box that is bolted to the receiver. When the converter is placed on the back of the receiver it is a simple task to insert the converter power plug into the octal receptacle. The connections from the octal socket to the internal wiring of the Command-set are shown in *Figure 16.*

Command-Receiver Modifications

The minor modifications to the Command set are shown in *Figure 16*. The leads to the octal plug must be installed, and the input circuit of the receiver modified. (Refer to the schematic of the Command-set shown later in this chapter.) Condenser *C-1*, neon tube *V-1* are removed from the receiver, and the "cold" end of *L-1* is disconnected from ground and attached to the B-plus line of the receiver. The B-plus terminal of coil socket *Z-5A* is bypassed to ground with a .01 *μfd* ceramic condenser. The grid end of *L1* is attached to the octal plug (*pin #3*) by a short length of low capacity coaxial line. RG-59/U will serve the purpose. *Pin #4* of the octal socket supplies B-plus to the converter oscillator, and pins *#7* and *#8* supply filament voltage and ground return.

Converter Adjustment

When the converter is completed and the wiring has been checked, a nearby receiver is used to monitor the crystal oscillator of the converter. The slug of coil *L2* is adjusted for stable oscillation. A drop of nail polish may be placed on the threads of the coil slug to lock it firmly in place. The grid tuning condenser across *L1* is then peaked for maximum receiver sensitivity in the center of the phone band.

Converter Operation on 10, 15 and 20 Meters

A modification of the oscillator circuit will permit operation of the converter on the higher frequency amateur bands, as shown in *Figure*

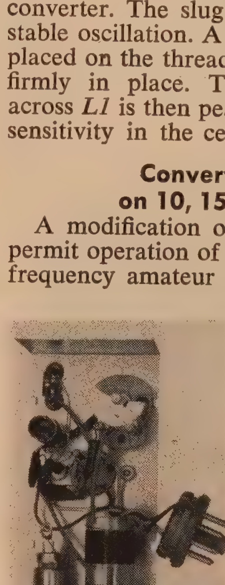
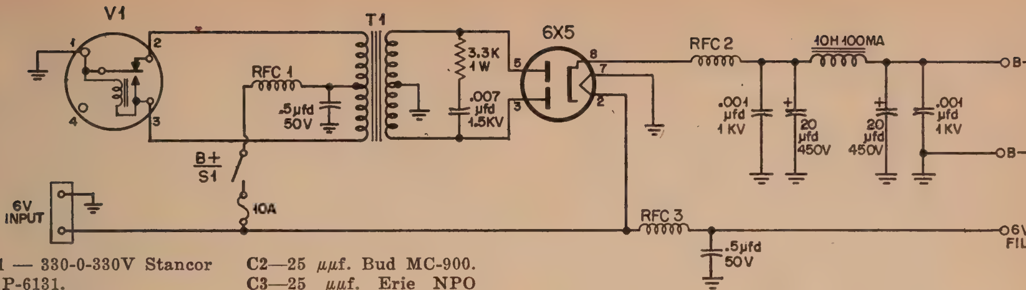


Fig. 17. Interior view of "Command" set converter.



T1 — 330-0-330V Stancor P-6131.
RFC1, RFC3 — .4 µH. Miller 5221.
RFC2—2½ mh. RFC. National R-100.
V1 — Vibrator. Mallory 500P with GC-7 grounding cup.
S1—Switch. ICA 1281.
C1—25 µµf. Bud LC-1642.
C2—25 µµf. Bud MC-900.
C3—25 µµf. Erie NPO 557-F.
C4—50 µµf. mica compression trimmer.
S1 — DPDT slide-type switch.
R1—2500 ohms, 4 watts for 200 volt supply. 5000 ohms, 10 watts for 250 volt supply.

Fig. 18. Vibrator supply for "Command" Receiver and converter.

19. To provide sufficient image rejection either the BC-946 (500-1500 kc) Command receiver, or the R-26/ARC-5 (1500 kc-3000 kc) receiver should be used. With the BC-946 a 7000 kc crystal may be used in the converter for 10 meter operation, and a 6700 kc crystal for either 15 or 20 meter operation. The crystals oscillate on their fourth harmonic for 10 meter operation, on their third harmonic for 15 meter operation, and on the second harmonic for 20 meter operation.

The converter is constructed in the same fashion as the low frequency version and tuned up in the same manner. The operation of the crystal oscillator may be checked by monitoring the harmonic frequency of the oscillator as *L2* is tuned through its range. The grid tuning condenser across *L1* is adjusted for maximum converter response at the middle of the amateur band.

a Single-tube Tunable Converter

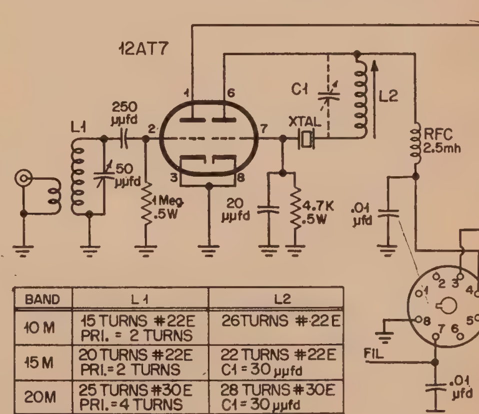
If all-band operation is contemplated it is much the wisest thing to purchase a switchable all-band converter rather than to attempt to build one. However, excellent single band operation may be had with a one-tube converter that is inexpensive to build and simple to assemble. For the mobile enthusiast who is content to operate a single band, a converter such as the one to be described will serve in a most satisfactory manner.

The circuit of the tunable converter is shown in *Figure 20.* A 6BA7 tube is used as a combined converter-oscillator. A single tuned circuit provides adequate image rejection when an intermediate frequency close to 1500 kc is used. A "hot cathode" oscillator circuit is employed, with the *#1* grid of the 6BA7 acting as the oscillator grid, and grids *#2* and *#4* acting as the oscillator plate. An OA2 regulator tube is employed to hold the plate voltage to the 6BA7 tube constant and independent of the primary voltage surges of the automobile system. Good frequency stability is thus achieved for 10 meter operation.

The plate circuit of the 6BA7 is resistance coupled to the input of the automobile receiver for simplicity. All i.f. selectivity is provided by the broadcast receiver.

Coil tables and frequency ranges of the various circuits of the converter are listed in *Figure 23.*

The assembly of this compact converter is shown in *Figures 21 and 22.* A small utility box measuring 3"x4"x6" (*L.M.B. Co.*) is used for the chassis-cabinet of the converter. If desired, a *Bud CU-2105* box (3"x4"x5") may be substituted for the somewhat larger box. The main tuning dial (*C2*) is mounted to the left of the chassis, and the input resonating condenser (*C1*) is mounted to the right. The tuning dial of the converter is a surplus vernier dial taken from one of the "TU-tuning units" of a



BAND	L 1	L2
10 M	15 TURNS #22E PRI. = 2 TURNS	26TURNS #22E
15 M	20 TURNS #22E PRI.=2 TURNS	22 TURNS #22E C1 = 30 µµfd
20M	25 TURNS #30E PRI.=4 TURNS	28 TURNS #30E C1 = 30 µµfd
COIL FORMS: CTC #LS3 WITH IRON SLUG 3/8 DIAMETER.		
CRYSTAL FREQUENCY 10 M = 7000 KILOCYCLES 15 M = 6800 KILOCYCLES 20M = 6700 KILOCYCLES		

Fig. 19. Fixed tuned converter for 10, 15 or 20 meters

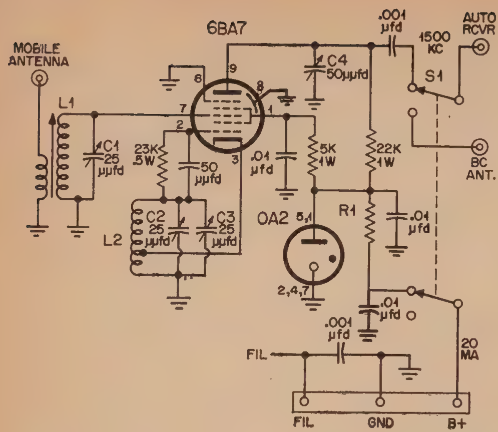


Fig. 20. Schematic, tunable converter

defunct BC-375 transmitter. *C2* is held at the front end by the dial coupling, and is affixed to the chassis at the rear end which is mounted on a short spacer. *C1* is attached directly to the front panel of the converter.

The 6BA7 tube is mounted inside the box in a horizontal position. The socket of the 6BA7 is affixed to a small aluminum angle bracket which is positioned about 2¼" behind the front panel. Coil *L1* and the socket components of the 6BA7 are mounted between the socket and *C1*. At the rear center of the chassis the OA2 regulator socket is mounted on short spacers. A small piece of heavy cardboard is placed under the socket to prevent the pins from shorting to the chassis. To keep the OA2 tube in the socket, a small bracket is fitted over the tip of the tube as shown in *Figure 22*. This bracket is held to the back of the box by means of a sheet metal screw.

Oscillator coil *L2* is mounted directly behind *C2* on a two terminal phenolic strip. Padding condenser *C3* is connected across the terminals of this strip. Resistor *R1* is mounted alongside the regulator tube, with the two output jacks on each side of it. The input jack is located in the lower back corner on one side of the OA2. In the opposite corner the selector switch, *S1*, and the power cord are placed.

Converter Wiring

A two terminal phenolic mounting strip is placed behind the 6BA7 socket, close to *C1*. The various condensers and resistors that connect to the socket prongs of the 6BA7 are mounted between the socket and this strip.

Fig. 21. The tunable converter. This single tube converter may be used on any amateur band between 10 and 80 meters.

Connections to the oscillator circuit are made with #16 tinned wire for maximum stability. The cathode lead between *pin #3* of the 6BA7 socket and the coil tap runs above the other components, well in the clear. It is the last connection made during the wiring process. A five wire cable is used for the power lead. Two leads of the cable are connected in parallel for the ground lead, and two are connected in parallel for the filament lead. The remaining lead is the B-plus wire. The 23,000 ohm grid resistor and 50 $\mu\mu$fd. coupling condenser connect directly between *pin #2* of the 6BA7 socket and the stator terminal of *C2*. Output padding condenser *C4* is connected between *pin #9* of the socket and the grounded rotor arm of *C1*.

Testing the Converter

After the wiring of the converter is checked, power may be applied for a test. The exact value of *R1* will depend upon the plate voltage applied to the converter. Current drain of the unit is about 20 millamperes, and *R1* should be chosen to provide the proper voltage drop at this current. Various values of *R1* for different applied voltages are shown in *Figure 20*.

Regardless of the band of operation of the converter, the oscillator tuned circuit (*L2-C2-C3*) must be tuned 1500 kc away from the received signal to produce a 1500 kc intermediate frequency signal to which the automobile broadcast receiver is tuned. Coil *L2* and padding condenser *C3* may be set according to the coil chart with the aid of a grid-dip oscillator. *L2* may be altered a turn or two to correct the frequency coverage, if necessary. In most cases, the correct frequency range may be hit by merely adjusting padding condenser *C3*. The r-f circuit, *L1*, *C1* should next be adjusted to cover the proper frequency range.

When this step is finished the converter may be connected to an antenna and the input circuit tuned for maximum response. The output padding condenser, *C4*, is tuned to provide maximum signal response when the converter is in the circuit.

Mobile Conversion of the SCR-274N Series "Command" Receivers

The SCR-274N series equipment makes an excellent foundation for mobile conversions. It is light, ruggedly built and so constructed as to make modifications a relatively simple matter. The following information is divided into two parts: 1—Conversion and modernization of the basic equipment for 80 and 40 meter operation, and 2—Conversion and moderniza-

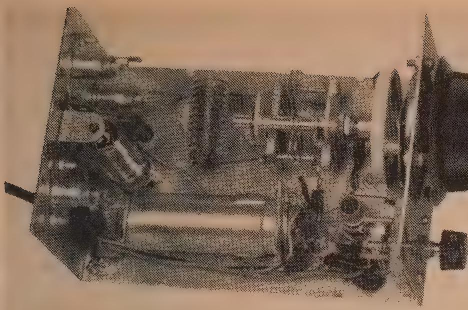


Fig. 22. Interior view of tunable converter. The 6BA7 tube is mounted horizontally beside the oscillator tuning condenser.

tion of the circuitry for 20, 15 and 10 meter operation.

The Original Equipment

The complete SCR-274N set makes up a multi-channel transmitting and receiving station for aircraft equipped with a 24 volt d.c. power supply. It will receive signals over the range of 550 kc to 9.0 mc. It will transmit A1, A2, or A3 signals over the range of 2.1 to 9.1 mcs. Identical items of equipment have various nomenclatures, as follows:

Receivers—

JAN Number	*Navy Number*	*Army Number*	*Ferquency Range*	*IF Freq.*
———	46129	BC-453	190-550 kc	85 kc
———	46145	BC-946	520-1500 kc	239 kc
R-25/ARC-5	46104	———	1.5-3.0 Mc.	705 kc
R-26/ARC-5	46105	BC-454	3.0-6.0 Mc.	1415 kc
R-27/ARC-5	46106	BC-455	6.0-9.0 Mc.	2830 kc

The JAN receivers differ slightly from the Army and Navy versions in that they have a.v.c., and employ a 12SF7 as the second i-f tube, rather than a 12SK7. They also have different connector plugs. A typical command receiver circuit applicable to all models is shown in *Figure 24*. Top and bottom views of a typical receiver with all parts indicated by Armed Service nomenclature are shown in *Figures 25* and *26*.

Physically, all the receivers are almost identical. The tuned circuits, the i-f transformers, and the padding condensers differentiate one from the other. By changing these components, for example, a BC-453 may be made into a BC-946.

The two high frequency receivers that cover 80 and 40 meters are not recommended for general mobile operation. Their i-f channels are too high, and the receivers tune too broadly for effective mobile operation. They are, however, useful as standby or interim equipment and, if they can be purchased cheaply enough, make a very satisfactory secondary receiver.

The low frequency (200-550 kc) and intermediate frequency (520-1500 kc) receivers make very satisfactory i-f strips for mobile converters. The receivers have high sensitivity and a very good order of i-f selectivity. The selectivity curves for all receivers are shown in *Figure 27*.

Six Volt Conversion of the Receivers

To rework the receivers for six volt operation is relatively simple. The filament circuit must be rewired as shown in *Figure 28* which places all the tube heaters in parallel. The tubes should then be replaced with their six volt equivalents.

If desired, the filament choke, *L-14*, may be removed from the receiver as it is of no use.

A small control panel should be made to fill the gap left by the removal of the switch panel adaptor plate on the front of the receiver. This panel should contain a volume control, a BFO switch and a speaker jack. The panel may be wired as shown in *Figure 29*, and then bolted to the front panel of the receiver. The leads from this panel are soldered directly to the jacks in *J-1*.

A very satisfactory tuning dial for the receiver may be made from a short length of 1/4" inside diameter copper tubing. Slot the tubing on both ends and use it as a coupling between the splined tuning shaft and a short length of 1/4" rod to which a tuning knob is attached. Fill the sleeve with duco cement or nail polish before fitting it over the splined shaft of the receiver. It will withstand rough usage.

A simple noise limiter circuit may be added to the Command receivers (*Figure 30*). It may be left connected permanently in the circuit and no additional controls are needed for it.

Coil Table, 10 Meter converter

L_1—14 turns #26 dcc, close wound on Millen #69041 form, ⅜" diam, ¼" long—tunes 28-30 mc

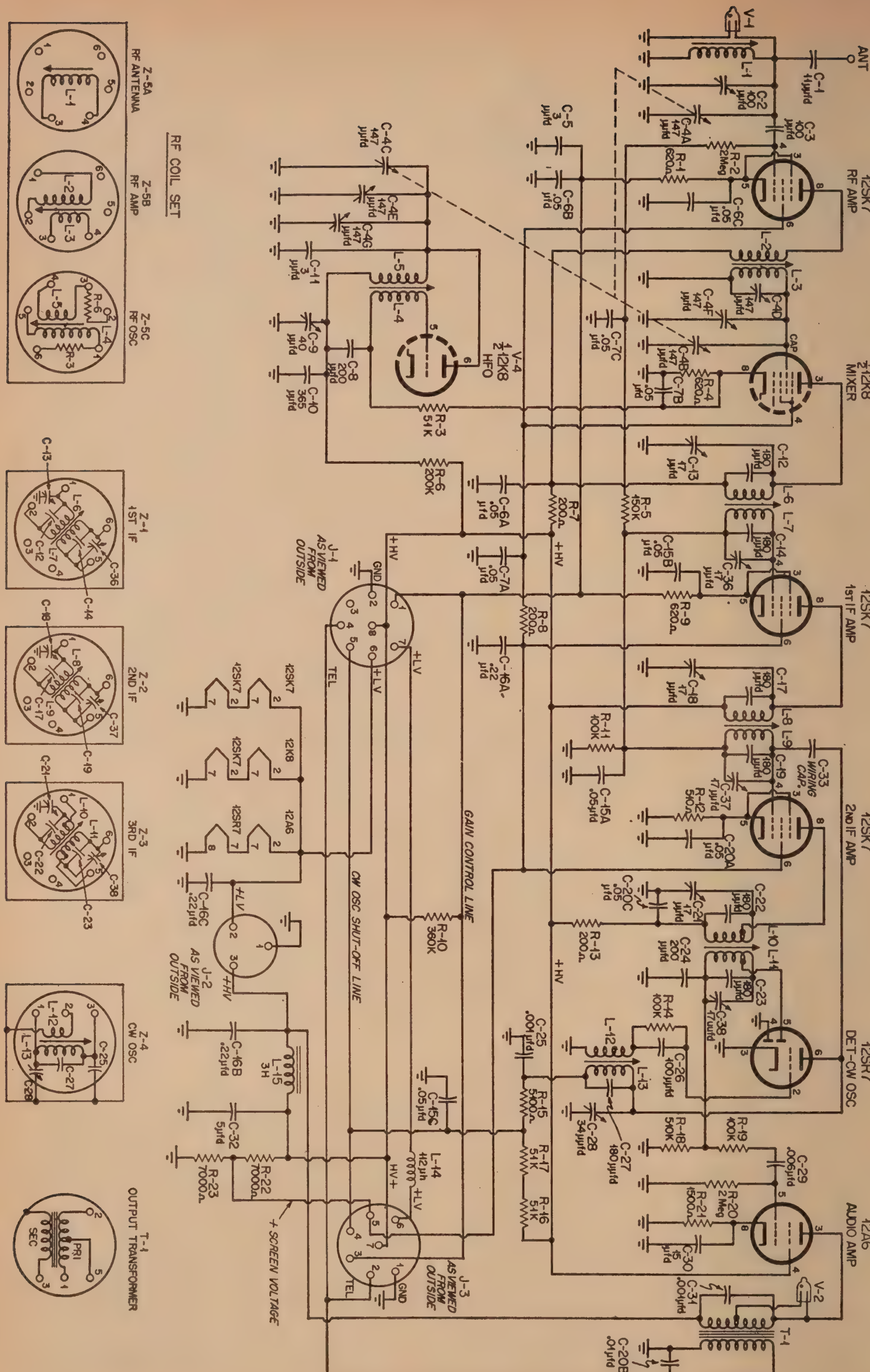
L_2—10 turns #16, ½" diam, 1¼" long. B & W 3002. Tap 2½" turns from ground end. Tunes either 26.5-28.5 mc or 29.5-31.5 mc for 1500 kc i.f. by adjustment of C3.

Conversion of the 3.0-6.0 Mc Receiver for Operation on 20, 15 and 10 Meters

The "80 meter" Command receiver will make a sensitive receiver for the high frequency bands. It is a good performer, even though the i-f selectivity leaves quite a lot to be desired. The conversions for the various bands are much the same, and consist of boosting the gain of the receiver and winding new r-f coils to cover the proper ranges. Let us examine the receiver changes first.

Receiver Modifications

1—To boost the gain sufficiently for 20 and 15



ANT
V-3 12SK7 RF AMP
V-4 ½12K8 MIXER
V-4 ½12K8 HFO
V-5 12SK7 1st IF AMP
V-6 12SK7 2nd IF AMP
V-7 12SR7 DET-CW OSC
V-8 12A6 AUDIO AMP
GAIN CONTROL LINE
CW OSC SHUT-OFF LINE
+ SCREEN VOLTAGE
J-1 AS VIEWED FROM OUTSIDE
J-2 AS VIEWED FROM OUTSIDE
J-3 AS VIEWED FROM OUTSIDE
RF COIL SET
Z-5A RF ANTENNA
Z-5B RF AMP
Z-5C RF OSC
Z-1 1ST IF
Z-2 2ND IF
Z-3 3RD IF
Z-4 CW OSC
T-1 OUTPUT TRANSFORMER

C-1—11 $\mu\mu$fd.
C-2—15 $\mu\mu$fd.
C-3, C26—100 $\mu\mu$fd.
C-4 (A to G)—147 $\mu\mu$fd., variables
C-5—3.0 μfd.
C-6 (A to C)—0.05 μfd.
C-7 (A to C)—0.05 μfd.
C-8, C24—100 $\mu\mu$fd.
C-9—40 $\mu\mu$fd.
C-10—365 $\mu\mu$fd.
C-11—3 $\mu\mu$fd.
C-12, C-14, C-17, C-19, C-22, C-23, C-27 —180 $\mu\mu$fd.
C-13, C-18, C-21—17 $\mu\mu$fd.
C-15 (A to C)—0.05 μfd.
C-16 (A to C)—0.22 μfd.
C-20 (A, B, C)—0.05/0.01/0.05 μfd.
C25, C31—0.001 μfd.
C-28—34 $\mu\mu$fd.
C-29—0.006 μfd.
C-30—15 μfd.
C-32—5.0 μfd.
C-33—wiring capacity.
C-36, C-37, C-38—17 $\mu\mu$fd.
L-14—choke, 112 uh.
L-15—choke, 3.0 h.
R-1, R-4, R-9—620 ohms.
R-2, R-20—2.0 meg-ohm.
R-3, R-16, R-17—51,000 ohms.
R-5—150,000 ohms.
R-6—200,000 ohms.
R-7, R-8, R-13—200 ohms.
R10—360,000 ohms.
R-11, R-14—100,000 ohms.
R-12—510 ohms.
R-15—5100 ohms.
R-18—510,000 ohms.
R-21—1500 ohms.
R-22, R-23—7000 ohms.

Fig. 24. Basic receiver circuit schematic (see next page) and parts list. With the exception of the coils, this is the circuit of all of the war surplus 274N series receivers.

meter operation it is necessary to replace the 6SK7 i-f tubes with 6SG7 tubes. A 6SG7 tube should also be used in the r-f stage. No circuit changes are needed. For 10 meter operation, a 6AC7 or (better still) a war-surplus 717A tube should be used in the first r-f stage.

The socket connections for the 717A tube are the same as for the 6SK7. To use these high gain tubes at 10 meters, a few circuit alterations must be made:

A—Shunt a 620 ohm, 1/4 watt resistor across cathode resistor *R1*.

B—Bypass *pin 3, 5 and 6* of the r-f tube socket to ground with .001 $\mu\mu$fd. Ceramicons (*Erie 801-001*). Use short leads.

C—Shunt *R22* with a 10.000 ohm, 10 watt resistor to raise the screen voltage to about 140 volts.

2—If it is desired to use a coaxial line input to the receiver, the present antenna terminal should be removed and an *Amphenol 83-1R* coaxial fitting substituted in its place. Run a short length of small coaxial line from the fitting to terminals 1 and 6 of the r-f coil socket. Tie the shield to *terminal 6* and also to *terminal 3*. This will ground the shield. Antenna windings should be added to the r-f coils as shown in *Figure 31*.

3—Remove all but one rotor plate in each section of the tuning condenser. The plate that is left should be the slotted one, for alignment adjustments. These plates may be easily removed by flexing them gently with a pair of long nosed pliers.

Coil Modification

When the receiver modifications have been made the coils should be modified as shown in *Figure 31*. Remove the plug-in coil unit from the bottom of the receiver, noting that it is polarized by the pin arrangement of the three coils. Remove the coils from the shield can, one at a time, and remove the cores from the coils. The cores should be replaced after the coil modifications have been made. Core position is not critical. When the coils have been modified they should be replaced in their respective shields, the leads soldered and the coil unit placed back in the receiver. Turn on the receiver, and hunt for the signal from the h-f oscillator of the Command set in the station receiver. It should

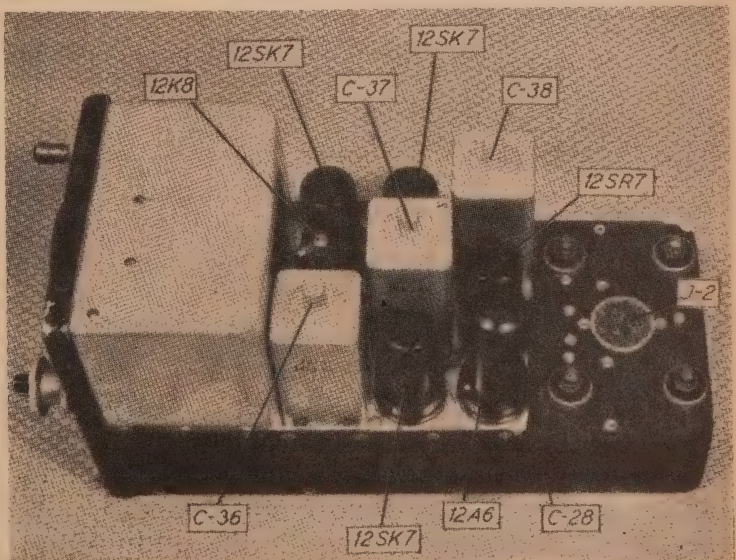


Fig. 25. Top view of a typical receiver. A bottom view of this receiver is shown in Figure 26.

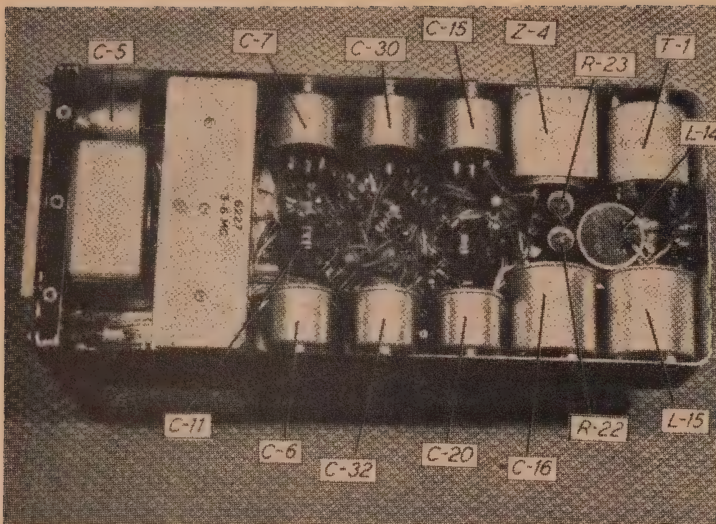


Fig. 26. Bottom view of a typical 274N series receiver. The nomenclature corresponds with that employed by the Armed Services in their Tech Manuals.

fall within the ranges indicated in *Figure 31*. Adjust the trimming and padding condensers *C-4* and *C-9* to give the proper bandspread. Do not disturb the wiring between the 6K8 and the oscillator socket. These leads are cemented in place and should not be moved or the calibration of the receiver will shift. Tracking may be improved by bending the slotted rotor plate of the oscillator condenser. It is possible, by proper adjustment, to employ the original dial lines with new figures for the new ranges.

When the mixer and r.f. coils have been rewound, trimmers *C-2*, *C-4F* and *C-4D* should be adjusted to bring in signals when a short length of wire is used for an antenna. Slight adjustment of coil turns spacing and adjustment of the slotted rotor plates may be in order to secure closed tracking of these two stages.

When this is completed, the tuning gang cover should be replaced, and the coil set bolted into place. Retouch the r.f. alignment of the receiver and the conversion is complete.

a Two Meter Mobile Converter

This small converter covers the range of 144-148 Mc. and is designed to work in conjunction with mobile converters covering the 10 meter region. It has an excellent signal to noise figure and is very inexpensive to construct.

The problem of obtaining an efficient converter for the 2 meter band is a hard one. Two difficulties stand in the way:

1. It is impractical to use the usual 1500 kc i-f channel for a two meter converter since the image frequency is only 3 Mc. away from the received signal. R-f selectivity comes hard at 2 meters and image rejection with such a low i-f would be poor. An i-f of at least 5 Mc. is called for. The solution to this problem is to use two i-f channels. Using the 10 meter input to the converter provides us with a 28 Mc. i-f channel, placing the 2 meter images 56 megacycles away from the received signal. Selectivity is provided by the 1500 kc output frequency of the 10 meter converter and by the low frequency i-f of the car receiver.

2. Experience has shown that the local oscillator used in any v-h-f converter has to be extremely stable to permit using a typical broadcast receiver as part of the i-f system. For best results, the v-h-f oscillator should be crystal con-

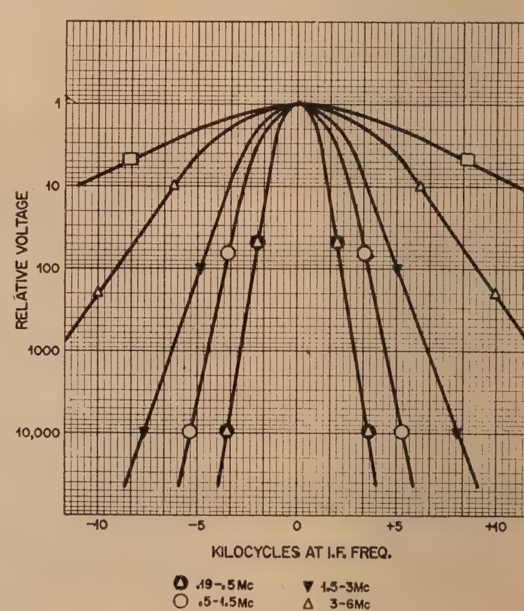


Fig. 27. Selectivity curves for the Command receivers.

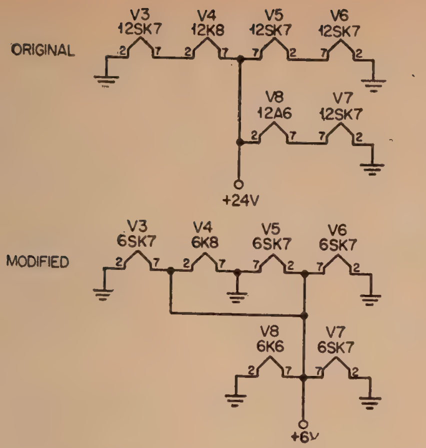


Fig. 28. Filament rewiring schematic for conversion to operate from a 6-volt source.

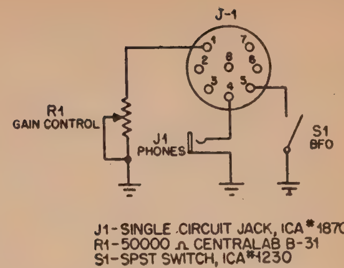


Fig. 29. This diagram shows the necessary components needed in the small switch plate box on the front of the typical 274N receiver.

trolled with a variable oscillator working at some lower intermediate frequency. Suitable crystals in the 8 Mc. region are inexpensive and most of them will oscillate on their 7th overtone mode.

The block diagram in *Figure 32* illustrates how these solutions are applied in this converter. The received 144 Mc. signal is amplified by a 6AK5 r-f stage and fed to a triode connected 6AK5 operating as a converter tube. An 8134 kc crystal operates in an overtone oscillator-tripler using a double triode 6J6 tube. The output of the 6J6 is on 170.82 Mc. and is resonated by *L6*. This frequency is beat against the 144 Mc. signal in the 6AK5 converter, and the difference frequency produced—26.82 Mc.—is fed to the 10 meter converter. This frequency is converted to 1500 kc by the 10 meter converter and fed to the auto receiver.

The i-f range is roughly 23-27 Mc. This can be covered on the top band of the Gonset converter by making use of its "image response." The antenna trimmer permits peaking the converter on the 10 meter image which falls within this range. Any tunable 10 meter converter with the h-f oscillator operating on the low frequency side of the 10 meter band will work in this fashion. To make the i-f fall in the 10 meter band a crystal on 8190 kc. should be used, the i-f range then becoming 28-32 Mc. The complete schematic is shown in *Figure 33.*

The R.F. Design

A 6AK5 pentode is used as an r-f stage. The noise figure of this stage is good enough to permit excellent reception of all kinds of man-made noise in the typical mobile location. A cascode front end was not deemed necessary for mobile work. Emission bias is created by *R1*, and both cathode pins are grounded by a small strap of copper soldered across the socket terminals. A small metal shield cut from thin copper or aluminum separates *L1* from the plate circuit of the 6AK5. This shield may be seen in *Figure 34.*

A 6AK5 tube is employed as a triode mixer because its low plate resistance across *L7* tends to produce uniform gain across the 4 Mc. i-f band. The mixer is coupled to the r-f stage by link coupled tuned circuits to flatten the gain characteristics and to provide extra selectivity against v-h-f images.

The oscillator circuit was chosen because it can force a sluggish crystal to oscillate. If the oscillator drifts off on its own (with the crystal in the circuit) the number of turns on the grid coil *L4* should be reduced.

The frequency multiplier may be used as a doubler or a quadrupler to suit other crystal frequencies if so desired. It has more than enough output to drive the mixer. A piece of insulated hookup wire about 1 inch long connected to the multiplier plate and placed near the mixer grid wiring provides sufficient mixer voltage for correct operation.

Layout

The unit is built in a 2"x2"x4" box, *Bud No. CU-3003*. The placement of parts is not critical except that the plate coil of the r-f amplifier, *L2*, should be located somewhat apart from the grid coil and the shielding plate should pass between them, obstructing the view from one coil to another. No crystal socket is used, the holder pins are soldered to the appropriate terminals under the chassis. It is necessary to mount the crystal beneath the chassis to prevent

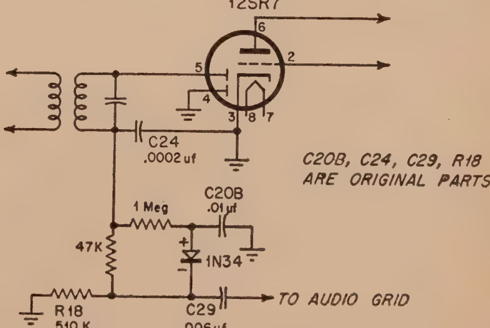


Fig. 30. This simple but effective noise limiter may be left in the circuit at all times.

Command Set Coil Winding Data

10 Meters

R.f. Stage (L1)—6 turns #18 enam. space wound to length of coil. Antenna coil has 2 turns to pins 1 & 6.

Mixer Stage (L2 & L3)—9 turns of original wire interwound with L3. L3 has 5 turns #18 enam. wound length of coil.

Oscillator (L4 & L5)—5 turns #18 enam. close wound, 1/8" from L4. L4 is unchanged. The oscillator tuning range for a 1415-kc i.f. is 29,415 to 31,115 kc.

15 Meters

R.f. Stage (L1)—8 turns #18 enam. space wound to length of coil. Antenna coil has 3 turns to pins 1 & 6.

Mixer Stage (L2 & L3)—13 turns of original wire interwound with L3. L3 has 8 turns #18 enam. wound length of coil.

Oscillator (L4 & L5)—7 turns #18 enam. close wound 1/8" from L4. L4 is unchanged. The oscillator tuning range for a 1415-kc i.f. is 22,415 to 22,865 kc.

20 Meters

R.f. Stage (L1)—11 turns #18 enam. space wound to length of coil. Antenna coil has 4 turns to pins 1 & 6.

Mixer Stage (L2 & L3)—18 turns of original wire interwound with L3. L3 has 11 turns #18 enam. wound length of coil.

Oscillator (L4 & L5)—10 turns #18 enam. close wound 1/8" from L4. L4 is unchanged. The oscillator tuning range for a 1415-kc i.f. is 15,415 to 15,765 kc.

spurious beats between the crystal and strong image signals.

L1, the r-f input coil is air wound and capacity tuned for maximum circuit Q. The other coils may be slug tuned. *L2, L3, L5* and *L6* may be wound on *Millen 69042* coil forms. The coil winding data should be considered only as a guide and the coils should be grid dipped at the specified frequency with all tubes in place.

The converter is designed to operate at a plate potential of 150 volts. If the plate supply puts out over 150 volts an external plate dropping resistor must be used. This resistor may be built into the power cable. The converter draws about 30 milliamperes at 150 volts, so a resistor of at least ten watt size must be used.

Wiring

Certain components may be mounted on the tube sockets before the sockets are bolted to the chassis. *Pins 2, 3* and *7* should be strapped on the 6AK5 r-f socket. *R1* and *C3* should be connected to their respective terminals. On the 6AK5 mixer socket jumpers between *pins 5* and *6*, and between *pins 2, 3* and *7* may be connected, and *R3* mounted. On the 6J6 socket *pins 3* and *4* should be jumpered and *R7* and *C7* connected. The sockets are now mounted in the chassis and the rest of the wiring completed. *Figure 35* shows the placement of the major components.

Testing

The coils should be first set to the proper frequencies by means of a grid dip oscillator. The unit should then be connected to a good a-c operated communications receiver. This will save battery, gasoline and upholstery of the car. A vacuum tube voltmeter or a d-c microammeter is used as a test instrument. Hook a 1/2 watt 100,000 ohm resistor to the tip of the probe to form a low capacity test probe. Apply plate and filament voltages to the converter and hook the output of the converter to the input of the communications receiver. Follow these steps:

1. Check the crystal oscillator. If it is oscillating it will develop a negative bias of several volts across the grid resistor *R7* of the multiplier. A normal crystal will go in and out of oscillation as *L5* is tuned through the resonant frequency. *L5*

COIL DATA

L1—Oscillator Grid—Self-supporting, airwound, 8 turns #18 AWG tinned copper on 1/4" O.D. mandrel, spaced to 1" overall length, center-tapped, both leads 1/2" long.

L2—Oscillator Plate—Self-supporting, airwound, 3 turns #12 AWG copper on 1/4" O.D. mandrel, spaced to approx. 3/4" length, center-tapped, leads less than 1/4" long.

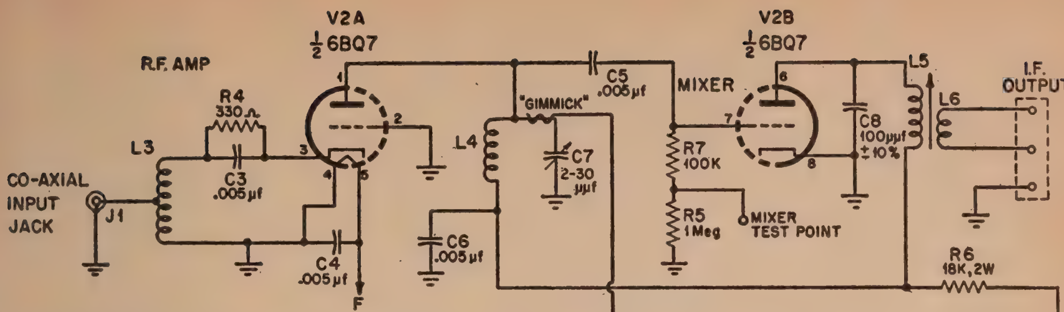
L3—R-F Input—Self-supporting, air-wound, 4 1/4 turns #18 AWG tinned copper on 3/8 O.D. mandrel spaced to approximately 1/2" overall length, tapped 1 1/2 turns up from grounded end. Leads approx. 1/4" long.

L4—R-F Plate—Self-supporting, air-wound, 2 turns #18 AWG tinned copper on 1/4" mandrel, spaced to approx. 1/2" length. Leads very short—less than 1/4".

L5—Mixer Plate—Make from parts of RCA coil type 202L-1. This coil uses a 9/32" thin-walled bakelite coil tube, a chassis mounting clip, powdered iron slug and a terminal collar. Remove all wire from original coil. Slip terminal collar to end away from mounting clip. Coat form with coil dope or Duco, then wind 30 turns of #30 AWG enameled copper wire, close-spaced as close as possible to the terminal collar. Use 2 of the terminals to anchor the coil leads.

L6—Output link—Wind approx. 10 turns of #30 enameled wire as close as possible to cold end of L-6. (This is the end nearest the mounting clip.) Twist L-6 leads together to hold coil in place and trim to reach terminal board as shown in illustrations.

L7—Oscillator Filament Choke—Self-supporting, air-wound, 20 turns of #20 AWG enameled copper close-spaced, leads approximately 1 1/2" long (trim to fit).



R1—56,000 ohm, ½w.
R2, R7—100,000 ohm, ½w.
R3—10,000 ohm, 2w.
R4—330 ohm, ½w.
R5—1 megohm, ½w.
All above resistors are carbon, ± 10% tolerance
C1—Main tuning, 3-6 µµf. per section—National VHF-1D (or equivalent—see text.)
C2—Oscillator trimmer, 3-12 µµf. NPO, Rotary ceramic—Erie TS-2A, Centralab 820-B
C3—r-f Cathode coupling, 5,000 µµf. + 100%—50%, Hi-K Ceramic disk type, 400 volt (min.), appro. ½" OD, Erie type 811, Centralab type 502 or equivalent
C4—Filament Bypass, same as C3
C5—R-F—Mixer Coupling, same as C3
C6—R-F—Mixer Decoupling, same as C3
C7—Mica Compression Trimmer, 2 to 30 µµf. ARCO type 461, Bud MT-833, National Type M-30 or equivalent.
C8—Mixer Plate, 100 µµf. ± 10% for 7 mc. i-f (for 5 mc., use 200µµf. for 10 mc. use 56 µµf.) mica or high Q ceramic, 400 V d.c. (min.)

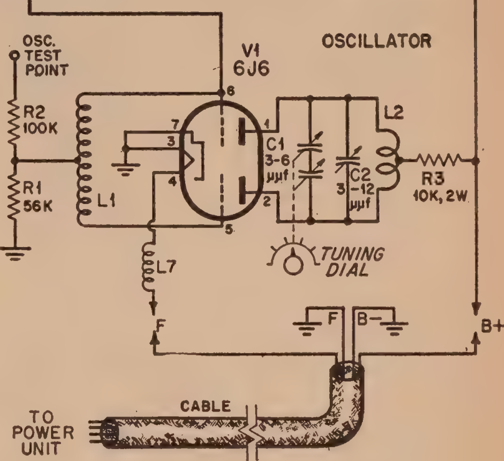


Fig. 32. Parts list and schematic for the 2-meter converter.

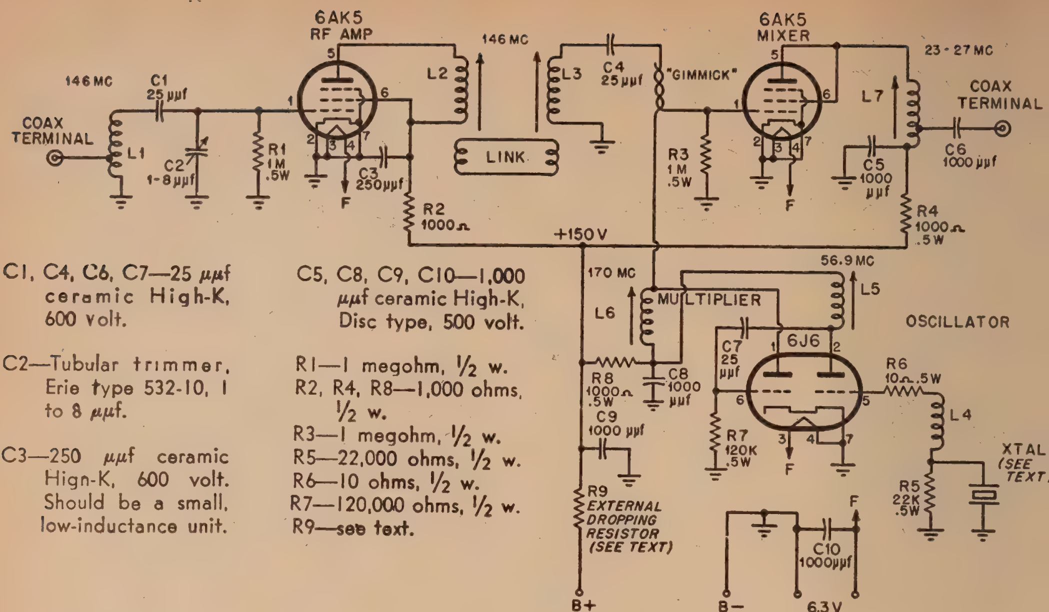
should be set slightly off the point of maximum output for best stability. If no oscillation occurs it will be necessary to increase the turns on *L4*. Use as few turns on *L4* as possible to prevent instability.

2. Check multiplier operation. It should be peaked for maximum negative bias across the 6AK5 grid resistor, *R3*. The wire coupling condenser should be adjusted to produce 5 volts bias across *R3*.
3. An increase in noise should now be noted when the communications receiver is tuned around the i-f region of 23-27 Mc. Set the receiver to 25 Mc. and peak the i-f coil of the converter, *L7* for maximum noise. Tune the mixer grid and plate circuits for maximum noise.
4. Connect a 2 meter antenna to the input of the converter. The antenna should be arranged for 50 or 70 ohm feed.

   A strong local signal of known frequency should be applied, and knowing the frequency of the signal, the frequency of the beating oscillator in the converter the resulting intermediate frequency may be computed. The communications receiver should be tuned to this frequency. If all is well with the crystal oscillator it shouldn't be hard to find the signal. It should give a T9 beat against the receiver BFO. The tuning adjustments in the converter should then be peaked up for best reception.
5. If the signal is not located where it should be on the communications receiver or if it sounds rough and unstable, the crystal oscillator is operating self-controlled. Tuning the crystal stage should clear the trouble. If not, the use of another crystal is suggested.

When operating normally the converter produces plenty of noise output to override the noise of the input stage of the 10 meter converter. Thus it controls the sensitivity of the entire system. The usual precautions should be taken in the automobile to minimize the effects of ignition, generator and regulator noise. A good ignition noise limiter is a "must."

The power to run the converter may be taken from the car receiver along with the 10 meter converter if the combined load does not overload the broadcast receiver. If this is the case, a separate supply must be used for the



C1, C4, C6, C7—25 μμf ceramic High-K, 600 volt.

C2—Tubular trimmer, Erie type 532-10, 1 to 8 μμf.

C3—250 μμf ceramic High-K, 600 volt. Should be a small, low-inductance unit.

C5, C8, C9, C10—1,000 μμf ceramic High-K, Disc type, 500 volt.

R1—1 megohm, ½ w.
R2, R4, R8—1,000 ohms, ½ w.
R3—1 megohm, ½ w.
R5—22,000 ohms, ½ w.
R6—10 ohms, ½ w.
R7—120,000 ohms, ½ w.
R9—see text.

Fig. 33. Simple Converter. Millen #69042 coil forms may be employed for L2, L3, L5 and L6.

2 meter converter.

As a final touch, an auxiliary switching box may be added to the 10 meter converter to facilitate switching its input from the v-h-f converter to lower frequency antennas.

Five small dots, applied with a fountain pen to the dial of the ten meter converter serve to indicate the megacycle markings on the two meter band, and show up well at night due to the indirect illumination of the dial.

a "Simple-Super" for 144 Mc.

The "mobileer" who looks to v-h-f operation is confronted with a definite receiving problem. He requires a receiver with the best possible sensitivity. An effective noise limiter is essential. Good stability under conditions of shock and changing battery voltage are also important. The selectivity offered by the narrow band-pass of an automobile broadcast receiver when used as an i-f system usually requires constant retuning during mobile net operations on two meters, due to the drift of transmitters and the usual tolerances on crystals.

The simple superregenerative receiver offers a possible solution, and has been widely adopted for v-h-f mobile work. But unless the entire receiver is well shielded and equipped with an r-f stage to isolate the detector from the antenna, it may radiate and interfere with other receivers in the immediate vicinity. The usual v-h-f superregenerative receiver tunes much too broadly, and is erratic in oscillation across a wide frequency range, such as the 144 Mc. band. On the credit side, a properly de-

COIL WINDING DATA: FIG. 33.

L1—R.F. amplifier grid coil; air-wound, #16 AWG copper, 5/16" ID, 5 turns, spaced to ¾" long, leads approx. ¼" long. Tapped approx. (see text) 1 turn from cold end. Should tune to 146 mc.

L2—R.F. amplifier plate coil; close wound on 9/32" OD thin-walled bakelite tubing with #18 AWG vinyl-insulated "bell wire." 5 turns, leads approx ½" long. Tuned by powdered iron core (see text). Should tune to 146 mc.

L3—Mixer grid coil, same as L2.

Link—Two turns around cold end of L2, same around L3; interconnection leads short as possible.

L4—Crystal osc. grid coil; Wound using a 1 meg 1 watt insulated resistor as a form, approximately ¼" diameter, 13 turns #24 AWG enameled copper wire, spaced to 5/8" winding length. See text.

L5—Crystal oscillator plate coil, wound on coil tube similar to L2, 8 turns #30 double-silk-covered copper wire, close spaced. Tunes to approximately 57 mc.

L6—Multiplier plate coil; Similar to L2 except only 3½ turns, with leads approximately 1" long. Tunes to approx. 170 mc.

L7—I.F. output coil; Made from a 21 mc. TV sound i.f. transformer, original windings removed, coil form approx. 9/32" OD, new winding 35 turns close-wound #30 AWG double-silk-covered copper wire, tuned by powdered iron core, tapped 10 turns from cold end. Tunes to 25 mc.

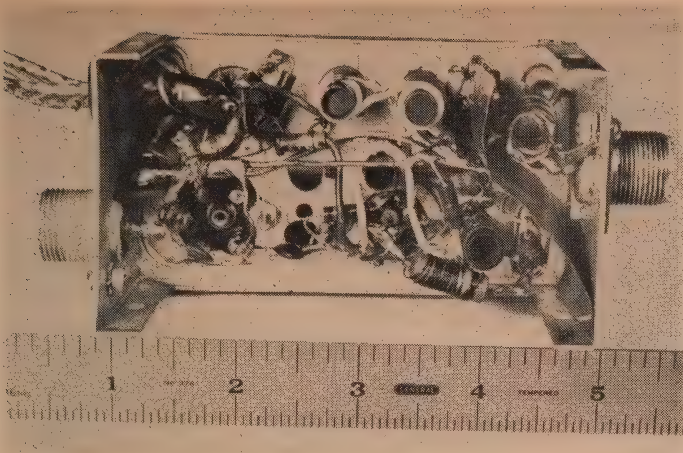


Fig. 34. Under-chassis view of the mobile 2-meter converter.

signed superregenerative detector discriminates against ignition and similar pulse-type noises.

Many of the disadvantages of the simple superregenerative receiver may be overcome by combining it with the superhetrodyne converter. Experience has shown that such a circuit is easy to adjust for optimum performance, and the unit described herewith has no unstandard parts or tricky multi-purpose circuits. The end result is a receiver offering the full potential sensitivity of a low-noise triode r-f stage, a compromise bandwidth of about 200 kc, the good inherent noise discrimination of a superregenerative detector, and ample power output. It is self-contained, and about the size of a box camera. It may be used in the car, or used as an emergency receiver at home. The power requirements are low, and plate current may be obtained from a small vibrator supply, a dynamotor or from an automobile radio power system.

Circuit Description

One section of a 6BQ7 *(V1)* is used as a grounded grid r-f stage, the other section as a triode mixer. The antenna is directly coupled to the r-f stage cathode coil *L3*. This is an inherently broad-band tank circuit and does not require tuning. The r-f stage coil, *L4*, is tuned by a mica sandwich capacitor, *C3*. In the remaining half of the 6BQ7, the triode mixer, the grid leak resistor (*R5* and *R6*) is tapped to provide a convenient point for attaching a test meter during tune-up. (More on this later.) The output coil of the mixer, *L5*, is also tuned by a mica sandwich condenser, *C4*.

A 6J6 *(V2)* is used in the familiar T.N.T. oscillator circuit. Varying the amount of self-excitation by spreading the turns of the grid coil, *L2*, has a negligible effect on the frequency. The tuning capacitor is of the split-stator type and the rotor need not be insulated from ground. The mixer injection signal is taken directly from the grid circuit of the oscillator, as changes in the loading on the grid tank have less effect on the frequency of the oscillator than changes on the plate tank. A "gimmick" coupling capacitor made from a short length of insulated wire hooked over the mixer grid lead provides sufficient coupling and ease of adjustment of injection voltage.

A 6AK5 *(V3)* is used as a superregenerative second detector, operating on an intermediate frequency of approximately 31 Mc. Basically, the circuit is the well-known tapped-coil Hartley, in which self-controlled quench action is obtained through the use of a large grid leak-grid capacitor time constant. Experiments have shown that in this circuit the quenching frequency should be quite low—just above the range of audibility—for best results. For this reason it is necessary to provide a quench-frequency filter to prevent overload of the a-f amplifier by the super-sonic output signal of the superregen detector. Resistance/capacitance type filters are used, including *C12, R9, R12,*

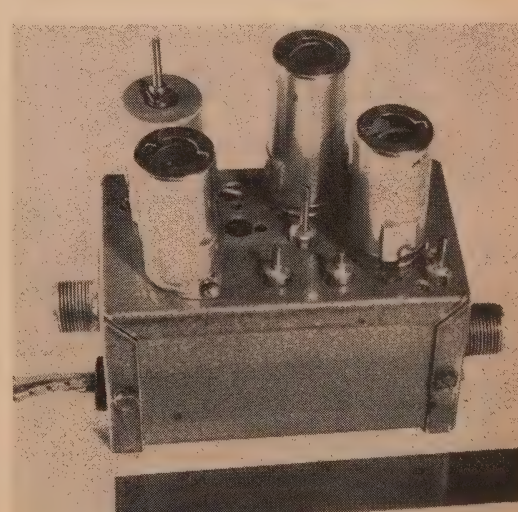


Fig. 35. The 2-meter mobile converter.

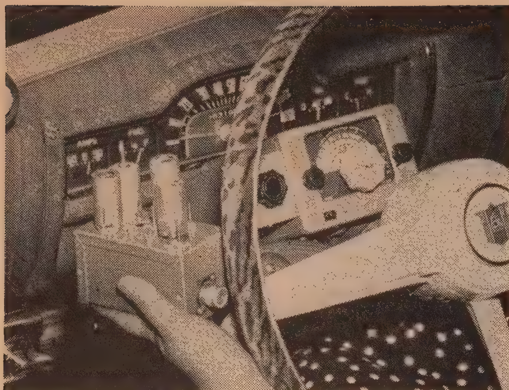


Fig. 36. The 2-meter converter, ready to be bolted to the side of the "Tri-Band."

and *C15*. The filtering also helps to eliminate much of the harshness of the usual superregenerative hiss. Regeneration in the detector is controlled by varying the screen-grid voltage with potentiometer *R19*. This control also tends to change the quenching frequency, which is lowered by raising the screen-grid voltage. This detector operates at very low voltages and displays unusually high sensitivity and reasonable selectivity. An i-f signal of about one microvolt can be copied easily—thus there is no need for additional i-f amplification. Signals are coupled between the mixer plate and the detector grid by means of a very small coupling condenser which is formed by hooking a short length of insulated hookup wire loosely around the plate and grid leads.

The audio output of this superregenerative detector is quite low, requiring considerable audio-frequency amplification. This is provided by *V4*, a 12AU7 connected as a conventional 2-stage resistance-coupled amplifier. This stage is coupled to the power output stage, *V5*, a 6AK6.

A panel view of this receiver is shown in *Figure 37*, and the complete schematic is shown in *Figure 38*.

Receiver Construction

The receiver is built on a 4⅛" x 3¾" x 1½" aluminum chassis (*Bud CB-1627*) and is housed in a black crackle finish 4" x 5" x 6" utility box (*Bud CU-729*). The chassis is laid out and drilled in accordance with *Figure 39*. If one has the facilities available to form his own chassis it should be cut and drilled for a small bracket for mounting the oscillator tuning condenser and audio output transformer. This bracket is shown in *Figure 40*. It should be fabricated from a rather sturdy piece of aluminum to insure a rigid mounting for the tuning condenser. The front panel is mounted to the chassis by means of the regeneration and volume control mounting nuts.

Fig. 37. 2-meter superhetrodyne.

A 1/32" washer should be slid on the threaded shafts between the chassis and panel to provide a fitting space for the lip of the cabinet. These washers may be made from the punchings of the socket holes. The condenser bracket is next mounted as shown in *Figure 41*. It is mounted to both the chassis and front panel with *4-40* machine screws, making the chassis, bracket and front panel one rigid unit. Tube sockets are mounted with *pin 1* toward center of chassis on all tubes except *V2* and *V5*. *V5* mounts with *pin 1* toward the outside of the chassis.

The oscillator tube socket is mounted on 1" metal standoff pillars using *4-40* screws; with *pins 2* and *3* toward the tuning condenser. The standoffs and screws were salvaged from a discarded rotary tap switch. The tuning condenser mounts with its short shaft toward the front panel. A lengh of fiber shaft is coupled to this short stub with a small flexible coupling (*Johnson # 104-154*). If too large a flexible coupling is used it will not clear the top of *V3*. A clearance hole must be drilled in the front panel to pass the tuning shaft. It is recommended that this hole be made large enough to clear any eccentricity of the tuning shaft. If one does not care to go to the expense of a vernier dial, a direct drive dial may be used, however, a friction drag should be provided to prevent turning of the condenser by vibration. Trimmer *C3* is secured to the chassis by the same bolt used to mount tube socket *V1*. *C4* is bolted to the chassis between *V1* and *V2*. Similarly *C5* is bolted to a hole located on the center line of the chassis near *V4*. The exact location and position of the remaining parts may be ascertained by referring to the photograph of the under chassis *Figure 42*. A strip 1½" wide should be trimmed from the back panel to provide clearance for the antenna and power receptacles.

Wiring is simple and straightforward. All tube socket grounds should be made to lugs mounted under the tube socket mounting bolts. Bend these lugs to provide a short path to ground. The filament wiring should be dressed close to the chassis. Keep all wiring as short as possible, especially in the r-f and mixer stages. No r-f circuit lead should be longer than ½". Coils are self-supporting and may be located by reference to the photographs. Wiring details of the oscillator may be noted by referring to *Figure 41*. The 6J6 oscillator tube, *V2*, is mounted upside-down, the socket being supported by two metal spacers. The

grid coil is self-supported, between *pins 5* and *6* of the *V2* socket. Oscillator test point resistor *R2* is tied to the coil center tap at the junction with *R1*. Its end is left hanging in space after being trimmed. Short leads tie the plate *pins 1* and *2* to the bottom lugs of the tuning condenser. The oscillator plate hair-pin inductor, *L1*, is mounted on the two top lugs of the tuning condenser; and oscillator padder condenser *C2* is soldered across the hairpin close to the aforementioned lugs. *R3* is soldered between the center tap of *L1* and an insulated tie point on the vertical bracket. The plate voltage lead connects to the tie point and drops down in back of *C1* through a grommeted hole to junction of *R21* and *C19A*. The oscillator injection lead is dropped through the remaining grommeted hole—dressed clear of the chassis and wrapped one turn around the plate lead of *V1 (pin 1)* at the hot end of *L4* and *C3*. Take particular care that the "gimmick" lead does not make electrical connection with the plate lead of *V1*. *Pin 3* of the oscillator tube socket is grounded to a lug under the socket mounting bolt. *RFC1 (Ohmite Z-50)* is tied to *pin 4* and run through a ⅜" clearance hole in chassis

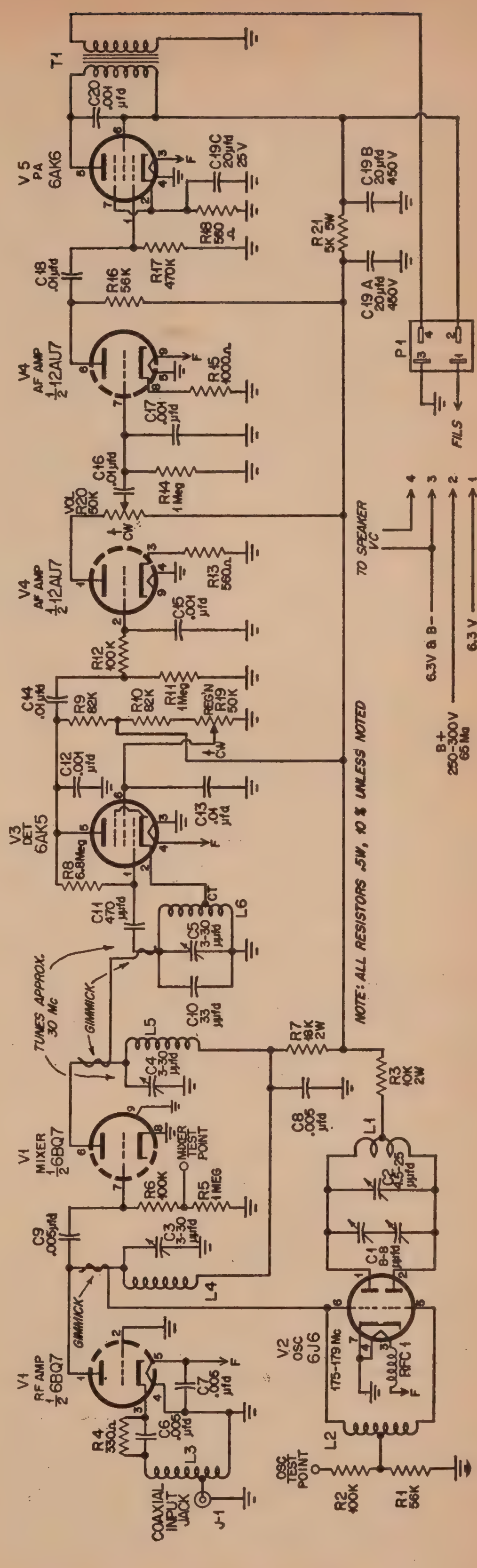


Figure 38. Parts list and wiring schematic.

C1—dual variable, 8 $\mu\mu$fd. per section (Bud LC-1659)
C2—4.5-25 $\mu\mu$fd. zero temp. ceramic trimmer (Centralab 822AZ)
C3, C4, C5—Mica compression trimmer (Bud MT833, Millen 27030, National M30)
C6, C7, C8, C9—5000 $\mu\mu$fd. disc ceramic (Erie 811, Centralab Disc Hi-kaps)
C10—33 $\mu\mu$fd. tubular ceramic (Centralab BC Hi-kap tubular)
C11—470 $\mu\mu$fd. tubular ceramic (Centralab BC Hi-kap tubular)
C12, C15, C17, C20—1000 $\mu\mu$fd. disc ceramic (Erie 811, Centralab Disc Hi-kaps)
C13, C14, C16, C18—10,000 $\mu\mu$fd. disc ceramic (Erie 811, Centralab Disc Hi-kaps)
C19—triple section electrolytic, 20-20/450v-20/25v. (Mallory FP345.8)
R1, R16—56,000 ohm, ½w.
R2, R6, R12—100,000 ohm, ½w.
R3—10,000 ohm, 2w.
R4—330 ohm, ½w.
R5, R11, R14—1 megohm, ½w.
R7—18,000 ohm, 2w.
R8—6.8 megohms, ½w.
R9, R10—82,000 ohm, ½w.
R13, R18—560 ohm, ½w.
R15—1000 ohm, ½w.
R17—470,000 ohm, ½w.
R19, R20—50,000 ohm potentiometer (IRC type Q)
R21—5000 ohm, 5w. wire wound
RFC1—r-f choke (Ohmite Z-50)
T1—single 6AK6 to voice coil. Pri-10,000 ohms, Sec-4 ohms (Stancor A3879, A3856 or equal)
J1—antenna jack UG-290/U (Amphenol 31-003)
P1—4-pin power plug, male, with angle brackets (Cinch-Jones P-304-AB)
V1—6BQ7 or 6BQ7A (RCA)
V2—6J6 (RCA)
V3—6AK5 (RCA)
V4—12AU7 (RCA)
V5—6AK6 (RCA)

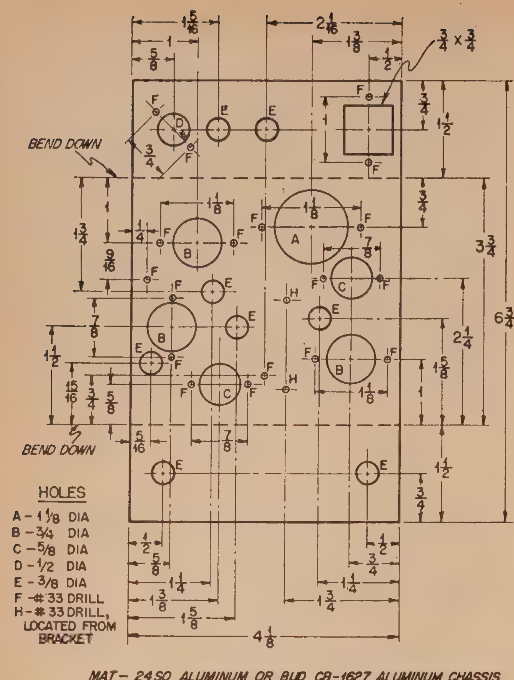


Fig. 39. Suggested chassis layout and drilling plan. The chassis is a BUD #CB-1627 and the cabinet is a BUD #CU-729. The method of mounting is discussed on this page.

to *pin 3* of *V4*. It is desirable to wrap *RFC1* with a layer of "Scotch" electrical tape or to slide it in a length of large-diameter spaghetti to prevent it accidentally becoming grounded to chassis.

A shield is required between the input and output coils of the r-f amplifier. It is made from a piece of flashing copper or metal from a "beer can." It is fitted in after all wiring is completed. One edge is soldered to the center post of socket *V1* and *pin 2*; the other edge is soldered to a lug under the antenna receptacle mounting bolts.

Test and Operation

Apply 6.3 volts to the filaments and 250-300 volts to the B plus circuit. Connect a suitable speaker to the output circuit. Turn the volume control *R20* fully clockwise and rotate regeneration control *R19* clockwise. This should produce a typical loud superregenerative hiss which should change gradually to a squeal as the control is rotated. This phenomenon indicates proper operation of the detector and audio stages. It might be well, at this time, to check the various voltages at the tube socket terminals. The voltages should approximate those listed in *Table 1*. The regenerative detector stage should be tuned to the vicinity of 30 Mc.

The exact i.f. should be selected in an effort to locate the image of your local TV channels out of the two-meter band. The local oscillator, operating on the high side of the two-meter band, will also receive signals on a frequency equal to the *sum* of the oscillator frequency and the i.f. If an i.f. of 31 Mc. is chosen, for example, the oscillator frequency range would be 175 to 179 Mc. and the image range would be 206 to 210 Mc. This range would include the sound channel of TV channel 12 (209.75 Mc.). By shifting the i.f. slightly lower (perhaps to a frequency of 30 Mc.) we can move this interfering signal out of the band—where it could be used as a marker!

The i.f. may be set either by listening to the oscillating detector on a communications receiver, covering the frequency range (it sounds like a broadly-peaked hiss), or by tuning in the output signal generator or grid dipper. (Don't be fooled by tuning to a harmonic or an r-f circuit response.) The intermediate frequency is set by padder *C5*.

The "gimmick" between *L5* and *L6* consists of a length of insulated hookup wire wound one turn around the detector grid coil lead and the mixer plate coil lead. It is a form of capacity coupling—capacity being varied by wrapping more or less turns around grid or plate lead as needed. When the capacity of the "gimmick" is correctly adjusted, tuning the mixer plate padder, *C4*, through resonance will cause the oscillating detector to "suck out" of oscillation. Coupling should be adjusted so that this effect is barely noticeable—as *C4* is tuned through resonance it should sound as though a weak signal were being tuned in on the detector. The detector should be just on the threshold of superregeneration for this test. After proper coupling is achieved, recheck the detector frequency and readjust as required.

The r.f. and mixer may be best aligned with a grid-dipper or a transmitter operating in the two-meter band. Remove the oscillator tube, *V2*. Insert a ¼ wavelength wire (approx. 19") in the antenna terminal. Connect a v.t.v.m. (set to the 5-volt d-c range) or a 200

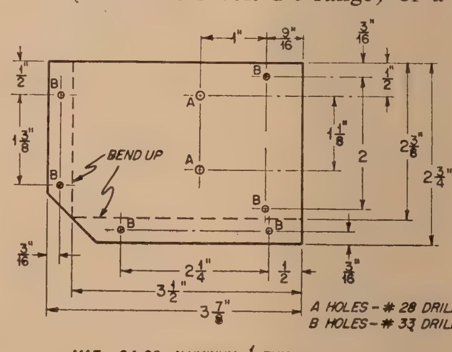


Fig. 40. Cutting, drilling and bending layout plan for the small bracket required to mount the oscillator tuning condenser, C1, and the audio output transformer T1.

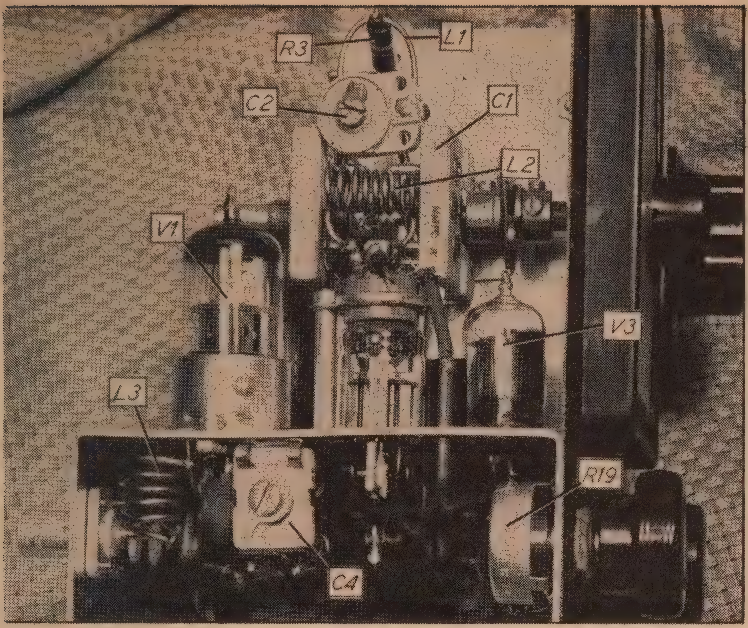


Fig. 41. Component layout of 2-meter superhetrodyne.

microamp meter between the mixer test point and ground. Ground is positive. Couple the 19″ antenna closely to the output circuit of the transmitter or grid dipper which should be tuned to 146 Mc. *C3* should be tuned to provide the greatest deflection of the meter, corresponding to the best gain in the r-f amplifier. *L3* is inherently broad-banded, no adjustments are required. Return the oscillator tube to its socket. Watch the mixer grid meter as oscillator padder *C2* is rotated. If the oscillator is putting out a signal, there should be a sharp increase in grid current as it passes through 146 Mc. Set the padder to *slightly less* capacity. Turn on a 146 Mc. signal source, which may be the grid-dip oscillator or a low-powered transmitter. Use *loose* coupling to receiver, or remove the antenna. Set *C1* at mid-scale and tune in the 146-Mc. signal by adjusting oscillator padder *C2*. Not much re-tuning should be required.

Next connect the test meter to the oscillator test point at the end of *R2*. Squeeze or spread the turns of the oscillator gril coil, *L2*, to produce a reading of 70 microamperes or (7 volts). Move the meter back to the mixer grid test point and adjust the coupling "gimmick" to the r-f stage plate lead to produce a reading of about 20 microamperes or 2.0 volts. (Injection voltage should not be less than 1.5 or greater than 5 volts.)

Connect an antenna and tune across the band. Tune in a signal as near to the center of the band as possible. Re-peak the r-f trimmer *C3* for maximum volume. Be careful not to tune the trimmer to a signal coming in via the image response! If in doubt that you are on the proper peak go back to the original test set-up and check the mixer grid current caused by your own transmitter or grid dip oscillator.

The receiver as designed provides approximately 120 degrees of band-spread. More band-spread may be obtained by bending the rotor plates of *C1* slightly outward. Decreasing the size of *L1* and increasing the capacity of *C2* will also accomplish the same results. Band-spread may be decreased by increasing the size of *L1* while at the same time decreasing the capacity of *C2*.

An access hole must be drilled in the case to permit adjustment of *C2* after final assembly. Installing the unit in the case might shift the oscillator frequency slightly. If so, locate a signal of known frequency and retune the oscillator padder, *C2*.

Power Supply

The unit may be operated from a separate vibrapack or a small receiving type of dynamotor supplying approximately 300 volts at 65 ma. If one cares to do a minor operation on the automobile broadcast receiver, power may be taken from this source. It will be necessary to install a switch to disconnect the filaments of the audio receiver to reduce the drain on the plate supply. Very few car receivers can stand the load required by this receiver—in addition to the normal load.

Antenna

The input impedance of the receiver, with the antenna coil tap as called for in the *Coil Table,* is approximately 50 to 75 ohms. This input impedance was chosen to match the conventional roof top ¼-wave antenna or coaxial mobile antenna.

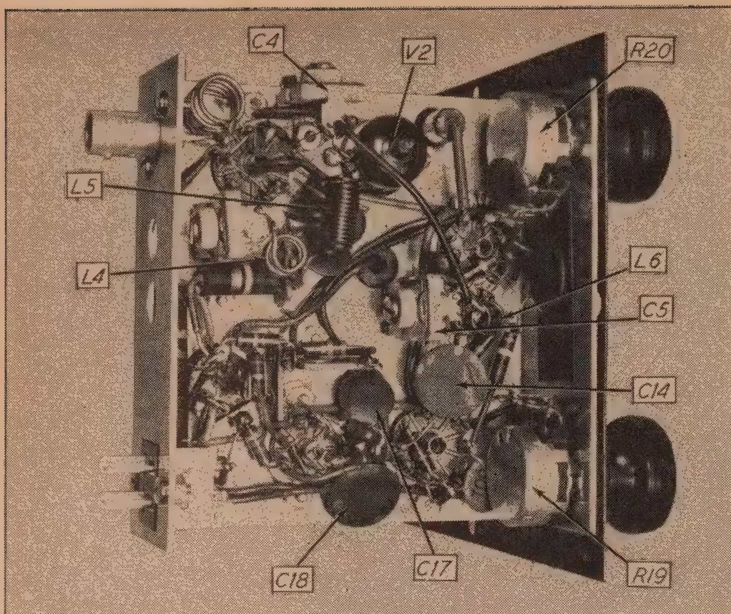


Fig. 42. Under chassis parts placement, 2-meter superhetrodyne.

the W2AEF Converter-ettes

Many amateurs desiring to enter the mobile field may partly be held from doing so for lack of an inexpensive method of reception. An inexpensive and simple receiving arrangement may also be desirable for use in automobiles serving as auxiliary listening units in connection with CD work.

The *Converter-ettes,* such as described herein, are ideal units to cope with the situation. They are simple two tube fixed-tuned converters of high sensitivity, which may be tucked away behind the dashboard, under the seat, in the trunk, or in the glove compartment. Tuning over the range of a band is done with the dial of the automobile broadcast receiver. The *Converter-ettes* have each been designed for single band operation. A typical unit is shown in *Figure 43*.

The R-F Stage

The circuit diagram for the *Converter-ettes* is shown in *Figure 44*. The r-f stage employs a 6BH6 pentode, the grid circuit of which is peaked to the center of the band by means of the slug in *L2*. Response is sufficiently broad for satisfactory gain over any one band. From the coil table it will be noted that fixed capacitors are added across both the r-f and mixer inductors for some of the bands.

The 6BH6 was chosen for the r-f stage because it provides high gain with a noise figure lower than that found with other tubes tried in this particular arrangement. The 6CB6, 6AK5, 6BA6, 6AU6, etc., may be used since from the practical standpoint, the attainment of the lowest noise figure may be a bit superfluous as far as *mobile* operation is concerned.

For CD work, or for other cases where very strong local signals may be encountered, provision has been made to use a.v.c. on the r-f stage to reduce front-end overloading and cross modulation.

The Mixer

The mixer-oscillator employs a 6U8 triode-

TUBE VOLTAGE CHART AS REFERRED TO IN TEXT.

TUBE	TYPE	USE	PIN NUMBERS 1	2	3	4	5	6	7	8	9
V1	6BQ7	RF MIX.	84	0	1.6	0	6.3	84	−1.5*	0	0
V2	6J6	OSC.	150	150	0	6.3	−9**	−9**			
V3	6AK5	DET.	−.1***	0	6.3	0	120	15***	0		
V4	12AU7	AUDIO	75	---	.6	0	0	100	---	3.5	6.3
V5	6AK6	P.A.	---	14	0	6.3	280	280	14		

NOTE: ALL MEASUREMENTS TAKEN WITH VTVM (VOLTOHMYST JR.)
B+ VOLTAGE MEASURED BETWEEN PIN 2, POWER PLUG P1 AND GROUND = 280 VOLTS DC.
** MEASUREMENT AT MIXER TEST POINT.*
*** MEASUREMENT AT OSCILLATOR TEST POINT.*
**** MEASUREMENT AT POINT OF REGENERATION.*

Voltage reference chart for 2 meter superhetrodyne receiver.

pentode dual purpose tube. The pentode section is used as the mixer, while the triode portion is used as the h-f oscillator. Other mixer tubes such as the 6X8 and the 6BA7 were tried, but the 6U8 provided the best all around performance consistent with high gain, low noise, oscillator stability, and minimization of oscillator pulling, to be found in one tube.

It will be noted that the output of the 6U8 mixer tube is fed directly to the input of the auto radio through a resistance coupled coaxial line. No special output circuits or low impedance links are required. This manner of coupling furnishes an output level higher than that found with some of the more conventional methods; in fact, the output from the *Converter-ette* is so high that in many installations it may be necessary to pad it down to prevent overloading and excessive a-v-c action in the broadcast set from only average ignition noise pulses.

The h-f oscillator employs a fixed tuned Colpitts circuit. Stray oscillator coupling to the mixer is sufficient through the tube capacitances. Similar types of broadband converters often employ crystal oscillators to realize stability, however, the oscillator used in the *Converter-ettes* has proven to be very stable, and no voltage regulation is required. This is possible because of the use of good components plus a high *C* oscillator circuit. The high *C* also reduces oscillator harmonics and thereby minimizes the possibility of image reception of signals from harmonically related high frequency bands.

Construction

The construction of the *Converter-ettes* is easy and quite straightforward. They are built on 4″ x 2⅛″″ x 1⅝″ chassis (*Bud Mini-box*). An aluminum shield, 1⅞″ wide and 1½″ high, separates the r-f stage from the mixer-oscillator section. The r-f section contains the following components, besides the tube socket for *V1: L1, L2, C1, C1A, C3, R1, R1A, R2* and *S1*. A three terminal tie strip is mounted along the mixer side of the chassis. One end of *R2* is connected directly at the socket of *V1, pin 6;* and the other lead of *R2* is insulated, and, after passing through a ¼″ hole in the shield, is connected to a common B plus terminal on the tie strip in

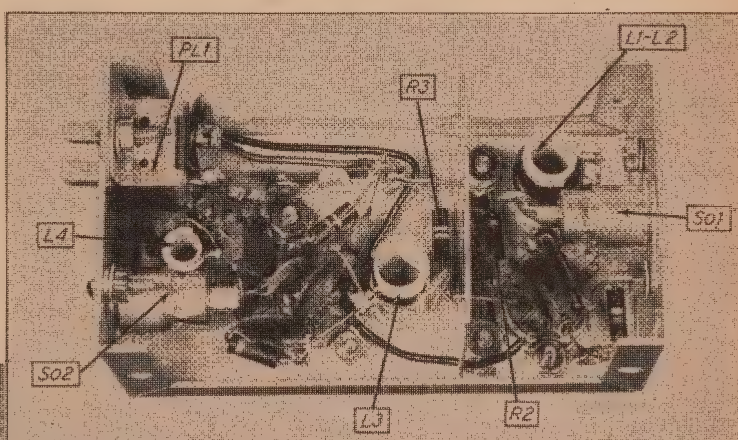
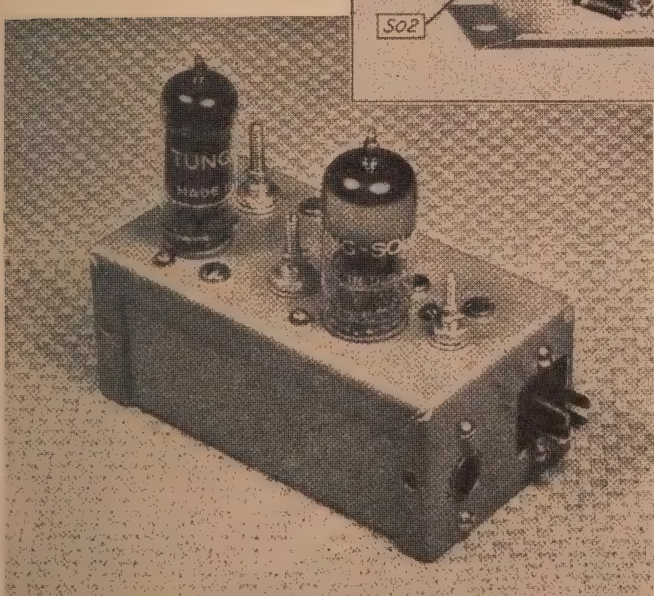
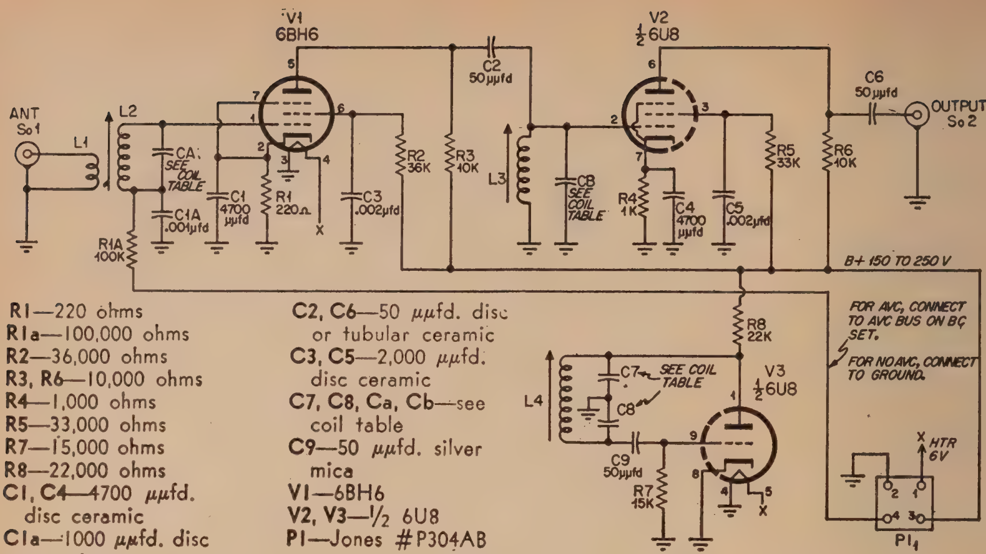


Fig. 43. Under chassis view of the Converter-ette showing the location of some of the more important components.



The Converter-ette may be built into a small BUD Mini-box. Each unit is complete for tuning one amateur band with the automobile receiver as a tuneable i-f system. Converter-ettes may be made to plug into a rack fitting for band changing.



R1—220 ohms
R1a—100,000 ohms
R2—36,000 ohms
R3, R6—10,000 ohms
R4—1,000 ohms
R5—33,000 ohms
R7—15,000 ohms
R8—22,000 ohms
C1, C4—4700 μμfd. disc ceramic
C1a—1000 μμfd. disc ceramic
C2, C6—50 μμfd. disc or tubular ceramic
C3, C5—2,000 μμfd. disc ceramic
C7, C8, Ca, Cb—see coil table
C9—50 μμfd. silver mica
V1—6BH6
V2, V3—½ 6U8
P1—Jones #P304AB

Fig. 44. Parts list and wiring schematic for the Converter-ette.

the mixer section. One lead of *R3*, located in the mixer section, is connected directly to the common B plus tie point. The other lead of *R3* is insulated, and after passing through a separate ¼″ hole in the shield, is connected directly to the socket of *V1, pin 5*. One lead of *C2* is connected to the end of *R3* before the latter passes through the shield hole, and the other lead of *C2* connects to the grid terminal of *L3* which is located near the shield partition. This grid terminal is the end of the winding at the top of *L3*. The ground side of *L3* is located at the end of the winding nearest to the chassis.

R5, R6 and *R8* are connected directly between their respective terminals on the *V2* socket and the common B plus tie point. The heater lead for *V1* is also brought through a separate small hole in the shield, and is connected to a common heater tie point terminal.

R1, R4 and *R7* are installed right at their respective socket terminals. They lie near the chassis with their ground ends connected to soldering lugs secured by the socket screws. One end of *R1A* is connected directly at the bottom end of *L2*, the other end is connected to an insulated wire which is connected to an a-v-c tie point terminal in the mixer section.

The oscillator capacitors, *C7* and *C8*, are installed vertically along the side of *L4*, away from the chassis to minimize heat pickup and to allow free air circulation around them. They are firmly secured by a short lead to a ground lug. The plate end of *C7* should be connected directly to the terminal on *L4* nearest the chassis. *C9* should be connected to the grid terminal of *L4* (the one farthest from the chassis) by a very short lead, leaving the longer lead to be connected to the tube socket. *C1, C1A, C4, C5* and *C6* are installed last.

Power leads for the *Converter-ette* are connected directly to a *Jones* plug mounted on the chassis, so that *Converter-ettes* for different bands may be plugged in at will.

Tube shields are not used, because they are not required, and because their use would transmit an excessive amount of heat from the tubes to the chassis. Good quality ceramic or mica-filled sockets hold the tubes securely in place without the aid of shields.

Adjustment and Operation

For 28 Mc. band operation, the oscillator should be tuned to approximately 28 Mc. This may be done by using a grid-dipper, no power being applied to the oscillator, but with the tube in the socket. With power applied, the oscillator may be checked for oscillation while using the grid-dipper as an absorption type

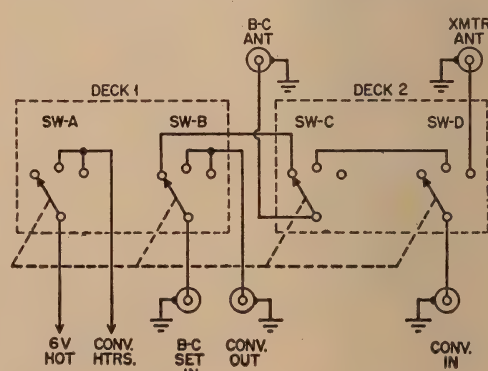


Fig. 45. A separate switching circuit provides a choice of antennas for broadcast reception as well as switching the Converter-ette into the broadcast receiver.

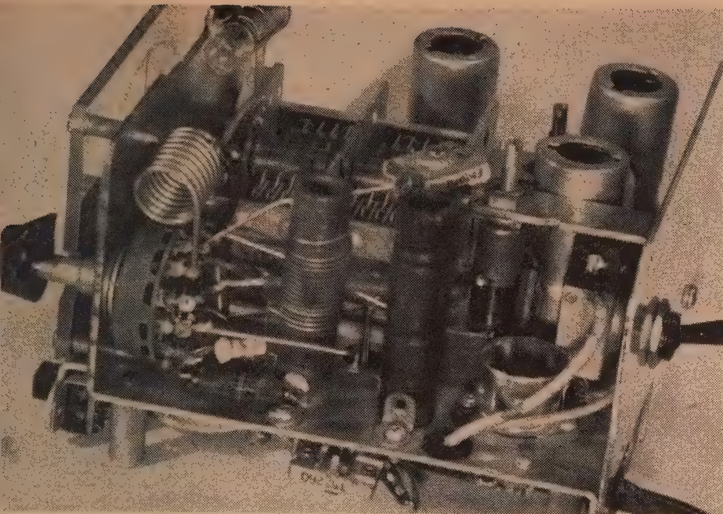


Fig. 46. 40-meter coil may be added to Tri-band converter, as shown.

requency meter. For better accuracy, another eceiver tuned to 28 Mc. may be used, in which ase the oscillator slug in *L4* should be adusted until the beat may be heard in the reeiver.

When the *Converter-ette* is used with a roadcast receiver, the h-f range will be 28 Mc. *lus* the frequency to which the broadcast reeiver is tuned. As an example, if the BC et covers 500 to 1600 kc., the h-f range will e 28.5 to 29.6 Mc. The low frequency range n many BC sets begins at 550 kc, in which ase the h-f range would start at 28.55 Mc. In his case, if it is desired to cover down to 28.5 Ac., the oscillator frequency of the *Converter-tte* will have to be lowered to 27.95 Mc. This, f course, will also reduce the upper frequency mit. If it is desired to bring the top of the ange to 29.7 Mc., then the oscillator frequency vill have to be raised to 28.1 Mc.

Next, if a grid-dipper is available, remove ne heater and plate power from the *Converter-tte* and peak the r-f and mixer inductors to pproximately 30.5 Mc. Apply both heater and late power to the unit. Recheck the inductors y using the grid-dipper. Because of the loading f the tubes on the low *C* circuits, the *Q* will e lowered, and it may be difficult to obtain an ndication on the grid-dipper meter. If a dip readable, the frequency will be lower beause of the change of the tube capacitances hen power is applied. The new resonances hould fall near, or be adjusted to, the center f the band.

If a grid-dipper is not available, the mixer nd r-f inductors should be tuned as follows: final retrimming should be made in this maner in any case). Connect the output of the *'onverter-ette* to the input of a receiver havg an *S*-meter which may be used as a visual eak indicator. If it is necessary to use a reeiver not having a meter, disable the a-v-c ircuit and use the loudspeaker or headphones to make peaking adjustments by ear. Do not connect any antenna to the *Converter-ette* at this time. Set the receiver near 1000 kc. Apply power to the *Converter-ette,* and make sure its oscillator is functioning at the correct frequency. Back off the slugs in *L2* and *L3* all the way counterclockwise. This is the highest frequency position. Now tune *L3* (mixer) slug clockwise until the thermal noise peaks, as indicated by the S-meter of the receiver. Note this point and again rotate the slug clockwise until a *second* noise peak is found. This second peak will be that on the *low frequency* side of the h-f oscillator and it is the *incorrect* one to use, but it should be checked in this manner so that it may be found which frequency actually is being peaked. Now rotate the slug back counterclockwise to the *first* peak originally encountered.

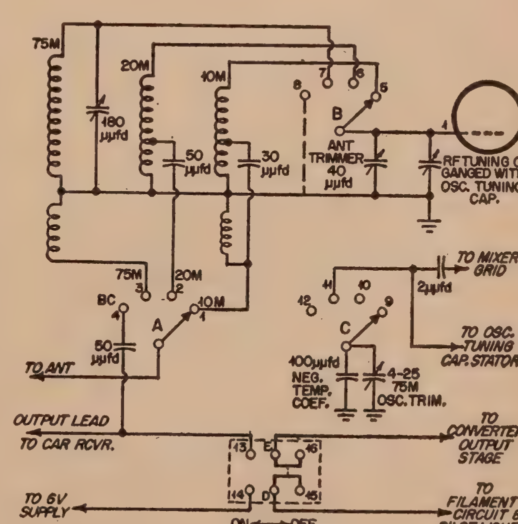


Figure 47. Tri-Band before modification.

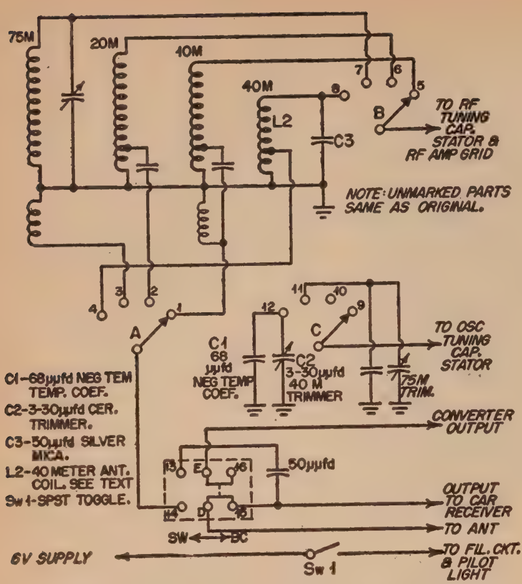


Figure 48. Tri-Band after modification.

Next tune *L2* (r-f) slug clockwise until the noise is peaked further. This should be the correct point on the high frequency side of the h-f oscillator, but the following additional check should be made:

First note the number of turns required from the maximum counterclockwise position to the point where the peak just found on *L2* has been determined. Then set the slug back at maximum counterclockwise, and tune the slug in *L3* (mixer) clockwise to its second or *incorrect* peak as described above. Then tune *L2* for a maximum peak, and count the number of turns from maximum counterclockwise at which the peak occurs. This should be a *greater* number of turns than counted with the first peaking of *L2*. Both settings of *L2* and *L3* will be the incorrect ones, since they are both tuned to the low frequency side of the oscillator, or at the image of the desired frequency. Here again, this operation is advisable just to check the correct peaking points.

Finally set both slugs back to their maximum counterclockwise positions, and proceed to tune them to the *correct* points by selecting the first peak (tuning in the clockwise direction) with *L3* (mixer), and then by peaking *L2* (r.f.) at the number of turns first counted. When the antenna is connected to the *Converter-ette,* it may have some slight reactance which may be tuned out by slightly repeaking *L2*.

Frequency Calibration

Final frequency calibration should be checked by tuning in signals of a known frequency. If the h-f oscillator is operating at exactly 28 Mc., the dial of the broadcast set will serve as the calibration for the whole band, and reference may easily be made by adding the broadcast frequency to 28 Mc. 600 kc on the dial then becomes 28.6 Mc., 700 kc becomes 28.7 Mc., 800 kc becomes 28.8 Mc., etc. If the h-f oscillator has to be shifted to take in the extremes of the band, as described earlier, then the dial calibration will be different by the amount the oscillator has been shifted.

The *Converter-ettes* for the other bands are lined up by following the same procedure as for 28 Mc., with the oscillator frequency tuned to the desired frequency *minus* the frequency to which the BC set is tuned. For example, on 14 Mc. it may be desirable to select 1000 to 1400 kc for the tuning range so that the calibration will fall in line, making 1000 kc equal to 14 Mc., 1100 kc equal to 14.1 Mc., etc. In this case the h-f oscillator must be tuned to 13 Mc.

On the other hand, the bandspread of the BC set may be too cramped in this range, in which case it may be more convenient to use, say, 600 to 1000 kc as the range. It is suggested that the range having the greatest bandspread be used, and if the BC dial is quite uniform, giving a choice of ranges, it is best to select the highest frequency end to obtain the best image rejection. Final peaking of the r-f and mixer inductors of the *Converter-ette* should be made at the center of the band used.

Installation in the Automobile

Upon installation in the car, any length of shielded antenna cable may be used to connect the *Converter-ette* to the BC set. In most cases it may be desirable to provide a switching arrangement, with appropriate shielded connectors, to change between *Converter-ette* and BC reception. This switching unit may be made up in a separate small box which may be mounted in an inconspicuous, but convenient, place. The circuit for one such arrangement is shown in *Figure 45*. A three position switch is used which permits the choice of normal broadcast reception on the BC set, or h-f reception through the *Converter-ette*. It also provides a choice of using either the normal broadcast antenna or the transmitting antenna on the *Converter-ette*. In addition, the heater supply for the *Converter-ette* is connected through to the BC set whenever the switch is placed in one of the h-f positions.

It will be seen that the broadcast antenna line is broken at two points through switches *B* and *C*. This, together with the separate switch decks, eliminates any possible leakage to the BC set of broadcast signals which otherwise might creep in when the *Converter-ette* is used.

If, when power for the *Converter-ette* is obtained from the BC set power supply, it is found that feedback or motorboating occurs when an h-f signal is tuned in, a decoupling filter should be installed between the *Converter-ette* and the BC set. This may be done at the

BC set. The filter should consist of a 1 watt 2000 ohm resistor in series with the B plus lead to the *Converter-ette*, with an 8 μfd. electrolytic capacitor connected between ground and the *Converter-ette* side of the resistor.

In certain cases the output from the *Converter-ette* may be too high causing overloading or excessive a-v-c action of the BC set. This may be reduced by padding down the output of the *Converter-ette* by means of a resistor connected between the output side of

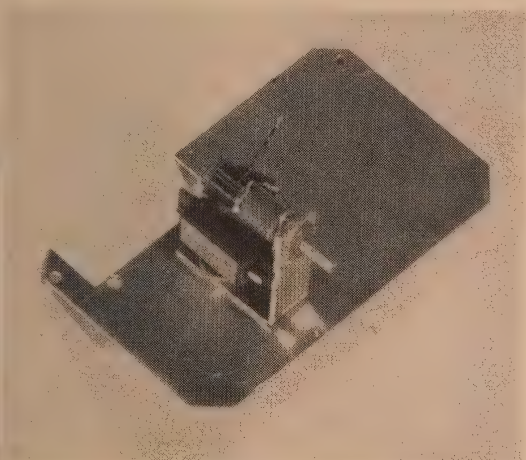


Fig. 49. 40-meter coil attached to back plate of "Tri-band" converter.

C6 and ground. The resistor will vary in individual cases, ranging from 100 to 3000 ohms. To find the correct value, set the volume control slightly above normal operating level, and disconnect the antenna from the *Converter-ette*. Then try different size resistors until the one is found which drops the thermal noise down to where it can just be heard.

Six Bands on the Tri-band Converter

The early model Gonset Tri-band converter may easily be modified to provide reception on all amateur bands between 10 and 80 meters. All that is needed is a coil, a couple of trimmer condensers and a toggle switch. No new bandswitch is required, no major rewiring is necessary, and no tracking problem is encountered.

In the Tri-band converter, the oscillator coil is not switched when changing from band to band. Only the antenna coils are changed. The basic frequency range of the oscillator is approximately 7450 kc to 9600 kc, and the second and third harmonics of the oscillator are used for 10- and 20-meter operation.

A consideration of the mechanics of tuning the bands already available on the Tri-band would indicate that to receive 40 meter signals it would be necessary to add an antenna coil for that band (*Figure 46*), and to move the oscillator frequency to get a range that is 1440 kc removed from the desired range of 7 to 7.3 Mc. and,—actually, that *is* all that is necessary. Experiment showed that by switching in enough capacity in the oscillator circuit to allow low-beat operation (oscillator tuning

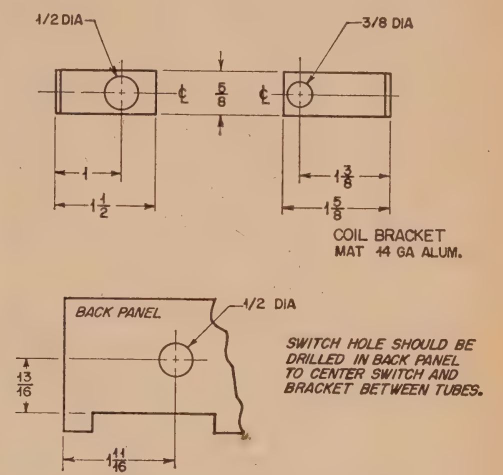


Figure 50. Coil bracket details.

5560 to 5860 to cover 40 meters) the 40-meter band could be set in the center of the tuning range of the converter, and the band is spread over a full rotation of the dial, with nearly perfect tracking.

While initially considering the modification, it was felt that a new band change switch would be required, with one more position, but once the technical details of oscillator frequency, etc., were out of the way, and the circuit diagram and layout of the converter was looked into more closely, it was found that the installation of a new band-switch was unnecessary.

Two switches will be found on the front of the converter: One, the rotary band switch, the other, a two-pole two-position slide switch. The fourth position of the band switch is marked "BC," and in this position, the antenna, which in the other three positions is switched to one of the converter antenna coils, is switched to the slide switch for transfer into the car receiver. So, as originally wired, it is necessary to put the band switch in the "BC" position and the slide switch to "Off" before regular broadcast signals can be received. By changing this arrangement, it is possible to make use of the "BC" position of the band switch to connect our 40-meter antenna coil and oscillator trimmer. To do this, it is necessary to rewire the slide switch, removing the filament con-

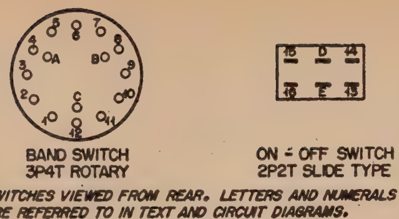


Figure 51. Tri-Band switch details.

trol from it to give us another section to do the antenna switching previously done by the band switch, and to add a toggle switch on the rear panel to switch the filaments on and off. Following this modification, the filaments may be left on or switched off, and the band switch can be on any of its four positions while you receive regular broadcast signals—only the slide switch need be used to switch from broadcast to amateur reception. *Figures 47* and *48* show the connections for both switches before and after modification.

The various problems involved in getting a coil of the proper inductance fitted into the available space were solved as shown in the chassis photos. The coil, wound with 18 turns #26 enam., tapped 4 turns from ground end, on a slug tuned form of ⅜-inch diameter and 1¼-inch length, is mounted from the back panel by means of a bracket held to the panel by the filament switch. Details of the bracket, and a drilling guide for the back panel, are shown in *Figures 49* and *50*. The method of assembling the switch, coil and bracket, and of mounting the assembly is shown in the photos.

In the actual work of wiring the modification, according to the following step-by-step procedure, reference should be made to *Figure 51,* which is a sketch of the rear of the switches, viewed from the left side of the chassis with the front of the converter facing away from you. Letters and numerals on this sketch are referred to in the following instructions, and on *Figures 47* and *48* as well.

Remove the back panel and the 6BH6 and 6C4 tubes from the converter. Drill a ½-inch hole in the back panel, according to the details in *Figure 50.* Mount the toggle switch and coil bracket temporarily, with the coil in place, to make certain that the switch and coil will clear the two tubes. Position the coil on the bracket so the coil leads come off slightly left of center of the coil toward the front of the converter. When you have made certain that the coil and bracket assembly can be put in place without interfering with the tubes, the back panel should be set aside for the present, until the wiring changes around the switches have been completed.

Access to the switch terminals can be facilitated by first unsoldering the 10-meter antenna coupling capacitor and shunt coil from terminal *1* on the band switch.

From terminal *C,* remove the wire which comes up from below the chassis through the large rubber grommet, and from terminal *11* unsolder the heavy bus-bar; interchange these two wires, bus bar to *C* and wire from below chassis to *11.*

Mount the 40-meter oscillator trimmer *C2* (3-30 μμfd. with 68 μμfd. negative temperature coefficient capacitor in parallel) on the under side of the chassis, behind the dial. Connect top leaf of trimmer to chassis, and the fixed plate to terminal *12* on the band switch.

Remove wire from terminal *4* of band switch; pull back down thru grommet and clip off at the point where it connects to the 50 μμfd. broadcast antenna coupling capacitor. Also clip capacitor lead at same point, as close to tie point as possible. Terminal *4* of the switch will be used for the tap on the 40-meter antenna coil.

On the slide switch under the chassis, remove the filament and pilot light leads from terminal *14.* (These leads may be on *D* rather than *14*—they are so shown on the manufac-

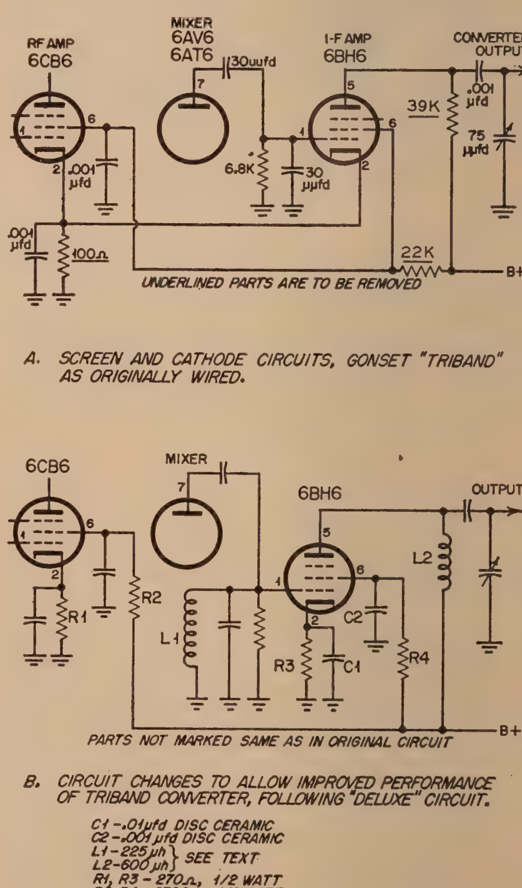


Fig. 52. Tri-Band screen and cathode circuits, before and after modification. Performance equals that of the new, "Deluxe" circuit.

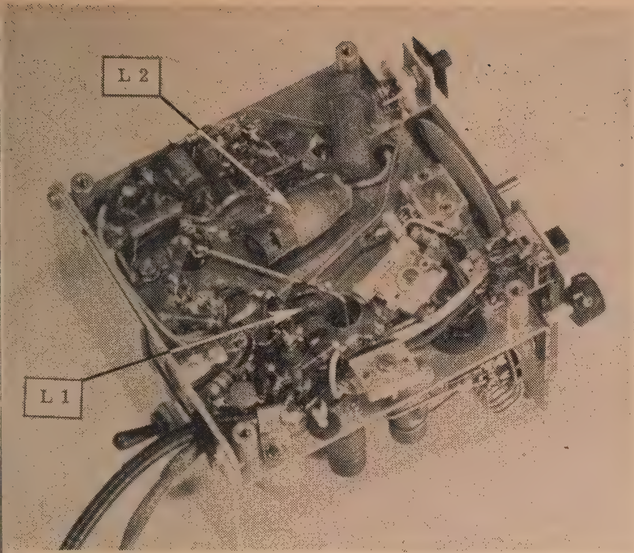


Fig. 53. I-f peaking coils L1 and L2 are mounted beneath the converter chassis.

urer's diagram, but were connected to *14* in the writer's converter.) Reroute pilot light ead to other side of chassis and connect to hot ilament connection of 6CB6 RF amplifier ube (*Pin 4*).

Unsolder hot 6 volt lead from terminal *D* or *14*—the opposite terminal from which you emoved the filament and pilot light leads). Work this lead, and the filament lead left from he last operation, back to the rear of the hassis, near the end of the power cable entering the chassis. Pull both of these leads off to one side temporarily.

Carefully drill a ⅝ inch hole near the edge of the chassis, about 1⅜ inches from the back ip of the chassis, between the 6BH6 IF tube and the 75-meter antenna coil. Insert a rubber grommet and pull the filament and 6 volt lead ip thru the grommet; solder these wires to the witch. The back panel, with coil and switch assembly, may now be mounted permanently.

Unsolder the wire from switch terminal *A*, and pull back down through chassis; reconnect o *D* of slide switch. Connect the free end of he 50 $\mu\mu$fd. BC antenna capacitor to *15*. The converter output lead on *13* is left untouched.

Connect terminal *14* to *A* on the band witch. This completes the wiring changes involved in the modification.

Connect the tap on the newly installed 40-meter antenna coil to *4* on the band switch, and connect the grid end of the coil to *8*. A connection from the ground end of the coil to the ground lug on which the 75-meter antenna rimmer is mounted (at the rear of the tuning capacitor) completes the modification. Reinstall the 10-meter coupling capacitor and shunt coil, and the converter should be ready for alignment and calibration.

Apply power and check the operation on 10, 20 and 75 meters. Performance on these bands should not be changed. Assuming the results of this check to be satisfactory, switch to the BC position and set the dial to zero, with the pointer just at the left edge of the 10-meter arc. With a signal of known frequency near 7.3 Mc. applied to the converter input jack, adjust the 40 meter oscillator trimmer under the chassis until the signal is heard at this dial setting. Set the antenna trimmer on the front panel to about ¾ maximum capacity and adjust the slug of the 40-meter antenna coil for maximum signal. Now, set the signal genera-

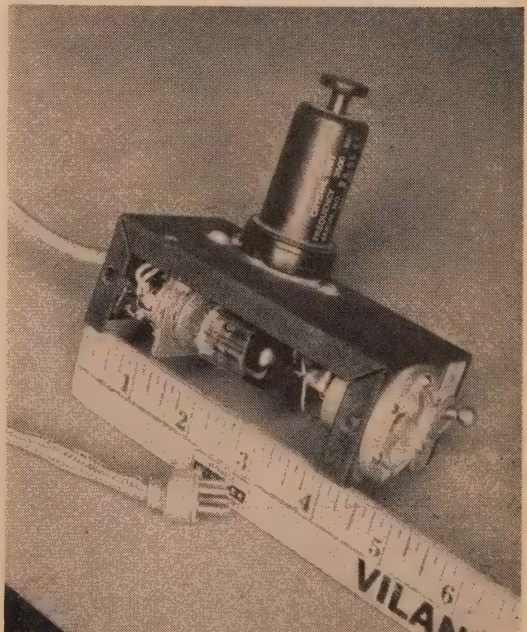


Fig. 54. S-meter and crystal marker.

tor to 7 Mc., and rotate the converter dial clockwise (pointer going counter-clockwise through the 75-meter arc) until you hear the signal again. You should find that the dial reads very near zero again, and the pointer will be between the 20- and the 75-meter arcs.

If desired, the dial may be calibrated at 100 kc points across the 40-meter region. To locate the 15-meter band, switch the converter to the 10-meter position and turn the dial clockwise. The 21-21.5 Mc. region will fall between 15 and 50 of the inner dial, at the extreme clockwise end of the tuning range on this band.

More Gain from the Tri-band Converter

In the original converter, coupling between the mixer and i-f amplifier, and between the i-f amplifier and the output was of the resistance-capacity type. By replacing these resistors, as shown in *Figure 52A* with small coils (*Figure 52B*) a satisfactory increase in gain may be had. Placement of these coils is shown in *Figure 53*.

The r-f and i-f amplifiers make use of common screen and cathode resistors and condensers. Replacing these with separate resistors and condensers for each cathode and screen circuit results in a further improvement in converter performance.

The exact values of inductance specified in the parts list need not be used, if coils of nearly the same value are available—the writer used 2 pies of a 1 mh. r-f choke for the 225 microhenry input coil, and the secondary of a small broadcast r-f coil for the 600 microhenry output inductance. Since exact resonance at the 1440 kc intermediate frequency is not being sought, any values reasonably near these should be satisfactory. The main problem is getting coils of approximately the correct inductance small enough to fit in the available space.

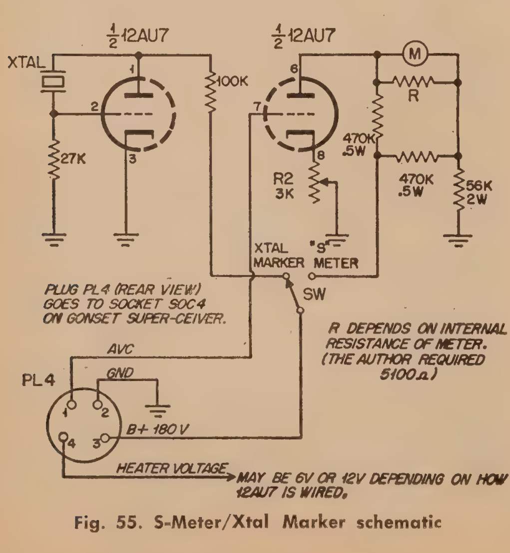


Fig. 55. S-Meter/Xtal Marker schematic

In removing pies from r-f chokes, for use as inductances in such cases, an approximation of the resulting inductance is made by assuming that the inductance of a coil varies approximately as the square of the number of turns. Therefore, removing two pies from a four-pie choke will give a coil of approximately ¼ the original inductance. This is not precise, but serves well enough for most applications.

One other change was made in the later converters: The user was given a choice, by means of a switch at the rear, of either high or low input impedance input on 75 meters. This involved switching the antenna to either of two primary windings on the 75 meter antenna coil. In a given installation the antenna impedance should be fixed, either high or low, so the switch should not be necessary once the impedance has been established. Therefore, this improvement could be quite simply had by experimenting with various sizes of primary windings on the 75 meter antenna coil, to determine the optimum impedance ratio in your own installation. In the case of the writer's converter, the coil as originally supplied proved to be just about right as it was.

The changes involved in bringing the con-

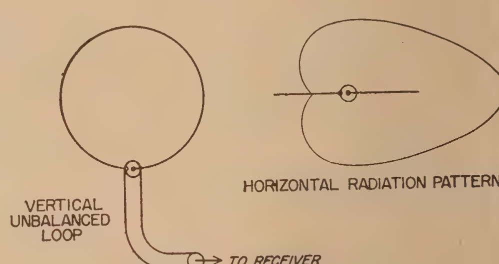


Fig. 56. Connections and directional pattern of the "Nobaloop."

verter up-to-date are few, and should be easy to make with the aid of the "before-and-after" diagrams attached; reference to the photo will give the approximate layout of the parts involved.

S-Meter and Crystal Marker for Mobile Receivers

Users of the Gonset Super-ceiver can easily add an external S-meter and crystal marker in the small package shown here.

The crystal marker is very useful to accurately calibrate the Gonset Super-6 converter on the various bands (via the trimmer on

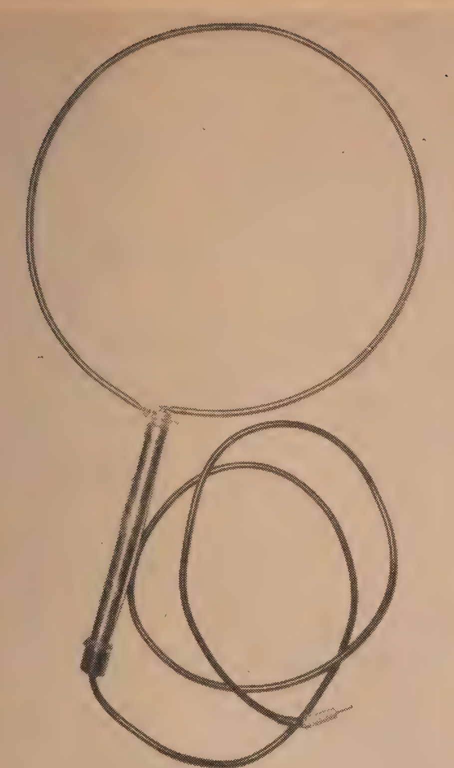


Fig. 57. Photograph of "The Nobaloop" complete, ready to plug into the mobile converter.

he converter). By using the BFO it also serves o double-check the accuracy of the transmit-er VFO on the various bands. Considering the xposure of the VFO to vibration and severe emperature variations, the crystal-marker heck is good insurance against possible greet-ngs from *you-know-who* for emitting a signal n the wrong frequency.

The S-meter is really more useful in peaking he antenna for various bands, or in trimming p the converter-receiver combination for max-mum performance. Actually little use is made f the S-meter in mobile operation for render-ng signal reports since the eyes should be kept n the road.

Luckily, an accessory socket (SOC4) at the ear of the tuning-head of the Gonset Super-eiver provides convenient connections for VC, GND, B+ 180 V., and heater voltage. he B+ will provide approximately 5 ma. con-inuous (adequate for the S-meter) and ap-roximately 25 ma. for a few seconds (for the rystal marker if only used for a short dura-ion).

This unit uses a twin-triode 12AU7 tube nd a small one-inch-diameter O-1 ma. meter o save space. The crystal is mounted externally o allow for easy change. The B+ toggle witch, mounted adjacent to the S-meter, witches the unit from S-meter to crystal marker. The unit mounts on the steering post adjacent to the converter. The small cabinet measures only 4¼″ long, 2¼″ wide, and 1½″ high, a standard catalog item (*Figure 54*).

A 3.5 Mc. crystal from a Command transmitter is excellent for accurately spotting 28, 21, 14, and 7 Mc. A 3900 kc PR crystal in the same socket spots the center of the 75 meter 'phone band. A regular 8-pin octal socket, properly wired, serves well as the crystal holder.

Adjustment: Turn the r-f gain to maximum, pull the tube and adjust resistor R across the meter for maximum reading. Replace the tube, switch on the BFO and adjust R2 for a zero reading. Now switch off the BFO and the meter should respond to the incoming signal.

The circuit of this unit is shown in *Figure 55*.

the Nobaloop

Herein described is the simplest of DF loops, with no ambiguity of direction. It has but a single direction of maximum signal and a single null. It was designed for locating signals on the ten meter band but has been used with reasonable success on the lower frequency bands.

W6WYA has used this loop in no less than 80 transmitter hunts, winning 15 first place findings and placing within the first 25 percent of early arrivals in nearly all the remaining hunts, which is excellent considering random factors involved in transmitter hunting—navigation, condition of roads and traffic laws.

The business end of the *Nobaloop* is a 38- to 46-inch length of copper tubing (¼-inch gasline is fine) bent into a neat circle. The ends are flattened for about half an inch in a plane perpendicular to the radius. Number 28 holes are drilled through the flattened tubing about ¼-inch in from the ends. The loop is attached to a coax receptacle such as Amphenol 83-IR or military type SO239. One loop end is attached to the outer conductor by a 6-32 screw through one of the four holes. The other loop end is placed over the receptacle's center-conductor lug and soldered heavily. This completes the loop.

Approximately 70 inches of RG-59U coax is used to connect the loop to the receiver, with appropriate coaxial plugs attached.

A suitable handle for the *Nobaloop* may be made of ⅝-inch brass or copper tubing 8 inches or so in length. This is secured to the knurled part of the loop's coax plug by solder. If both the cable plugs are too large to be fed

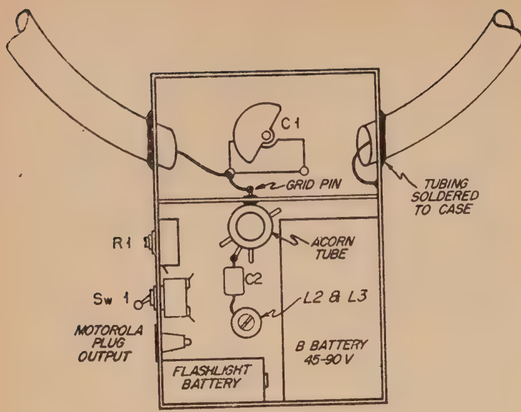


Fig. 58. Pictorial diagram of typical r-f amplifier loop, illustrating placement of parts. Although aluminum may be used, copper tubing is usually preferred because of its ease of handling.

through the tubing used, remember to slip the tubing over the cable before attaching both plugs.

How to Use

The loop is held by hand out the window a few inches above the top of the car. It is held with the hand near the loop for technical as well as practical reasons. With the loop held out the window, the receiver is tuned to the desired signal. Rotating the loop causes the signal to vary. Maximum signal is in the plane of the loop, in the direction of the ungrounded end of the loop (*Figure 56*).

Minimum signal is in the same plane but in the reverse direction, the direction of the grounded loop end.

When the received signal is weak, maximum signal is used for direction finding. When the signal becomes strong the sharper minimum signal, or null side may be used.

The signal received via the loop is about 25 percent of that received by the standard whip. A close-up of the *Nobaloop* is shown in *Figure 57*.

Direction Finding

There are two types of direction finding loops in general use. One type includes an r-f amplifier, and the other does not. Both give equally good directional indications, but the former provides considerably more gain. Generally speaking, the loop with the built-in r-f amplifier will allow you to copy any signal you can hear on the quarter-wave whip, while with the other type, signals below approximately *S5* or *6* will be unusable.

Let's take the more complicated amplifier loop first. Mechanically, it consists of a metal box containing the amplifier components together with the batteries to operate it, and the loop itself, which is made of ⅜ or ½-inch copper or aluminum tubing. None of the dimensions are critical. The loop can be made 10 inches in diameter separated at the top by ¼-inch or so, and the adjoining ends of the tubing wrapped with tape to maintain the spacing.

For 10-meter operation a single turn of small copper wire (#28 or #30) is pulled through the tubing. The wire should be covered with spaghetti or small glass beads for insulation and to keep stray capacity to a minimum. If the wire is too large or not kept away from the walls of the tubing, the distributed capacity may be too large to allow the loop to resonate at 10 meters.

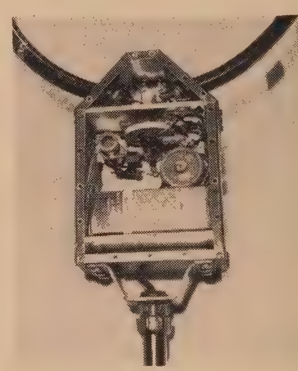


Fig. 59. Interior view of loop amplifier employing acorn tube.

Unless one has facilities for working aluminum, it is easiest to use a sheet metal box and copper tubing, securing the tubing to the box with heavy solder points.

Tubes best adapted to use in the amplifier are the acorn series, types 957, 958 or 959, requiring only a single dry cell for filament power. These tubes were plentiful on surplus until a short time ago and should be used if at all possible. If not obtainable, almost any small 1½-volt triode or tetrode will provide enough gain for satisfactory operation.

The circuit should be laid out in such a manner as to minimize coupling between the grid and plate components. Use of a shield is recommended between the grid tuning condenser and the rest of the circuit. If an acorn tube is used, only the grid pin need project into the grid compartment, everything else being outside the shield. The triodes, of course, will oscillate unless precautions are taken, and since neutralization never seemed to work out very well in this application, a filament rheostat can be installed and the filament voltage backed down until the tube is operating below the point of oscillation. A regenerative

triode amplifier used in this manner gives just about as much gain as a tetrode. Oscillations in the loop, when present, are evidenced by strong carriers heard in the receiver, which warble when the loop is tapped lightly.

Connection to the receiver is made with a length of 52-ohm coaxial line of appropriate length (preferably of the small variety).

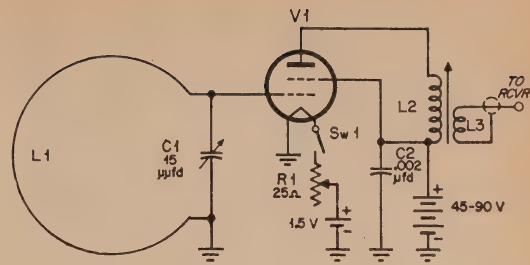
A diagram of a loop-amplifier is shown in *Figure 58.* Interior and exterior views are shown in *Figures 59* and *60.* The loop amplifier schematic is shown in *Figure 61.*

The Unshielded Loop

The second type of loop in common use, though unshielded and without r-f amplifier, nonetheless gives just as accurate indications as its bigger brothers, and fellows who use it on hunts ask for and are given no handicap or quarter.

The square loop shown in *Figures 62* and *63* is an example. This simple loop has brought its owner in first at many hunts and in competition with all manner of homing devices. It is constructed on a 12-inch square frame sawed from ¼ inch masonite or plywood, with a four-inch projection left on at the bottom to

Fig. 60. Exterior view of loop amplifier.



R1—25 ohm rheostat
C1—15 µµfd. air trimmer
C2—.002 µfd.
L1—single turn #28 (see text)
L2—15 turns #18E closewound on ½" slug-tuned form (National XR50)
L3—3 turns hookup wire wound on L2
Sw1—s.p.s.t. toggle switch
V1—1.5v triode or tetrode (see text)
Note—if triode is used, omit screen to B+ lead, but retain C2 in circuit.

Fig. 61. Parts list and schematic of loop and amplifier. Tube V1 can be almost any small 1½-volt triode or tetrode. R1 provides filament voltage control in order to prevent oscillation

serve as a handle. The 300-ohm twin-lead is fastened around the edge of the frame with electrician's tape. The coil must be shielded and the shield connected to the coil center-tap, one end of the pickup coil and the outside braid of the coax.

With the loop connected to the receiver input, there should be a definite increase in noise as the device is tuned through resonance, being quite marked in the amplifier-type loop and to a lesser but still noticeable degree with the simpler model. Either loop, however, will, at its resonant frequency, give a strong indication in a grid dipper held two or three inches away.

Is Your Loop Working Properly?

These are but two examples of successful direction-finding loops, and there are endless possible variations of design. Regardless of which type you use, there is one simple, infallible test to determine whether your loop is indicating correctly. Tune in a signal and rotate the loop until a dip in signal strength occurs. Take careful note of the loop's position, then turn it 180 degrees to the opposite direction. Another null or dip should appear exactly 180 degrees from the first. If it does, your loop is working perfectly; if not, your loop is not to be trusted. The nulls or sharp dips in signal strength occur when the plane of the loop is at right angles to the direction of arrival of the signal. An easy way to avoid confusion is to remember that when the loop is at the null point, you look directly through it at the hidden transmitter. Important factors in proper operation are equal pickup in both sides of the loop, and complete shielding to avoid r.f. pickup in any other portion of the circuit except the loop itself.

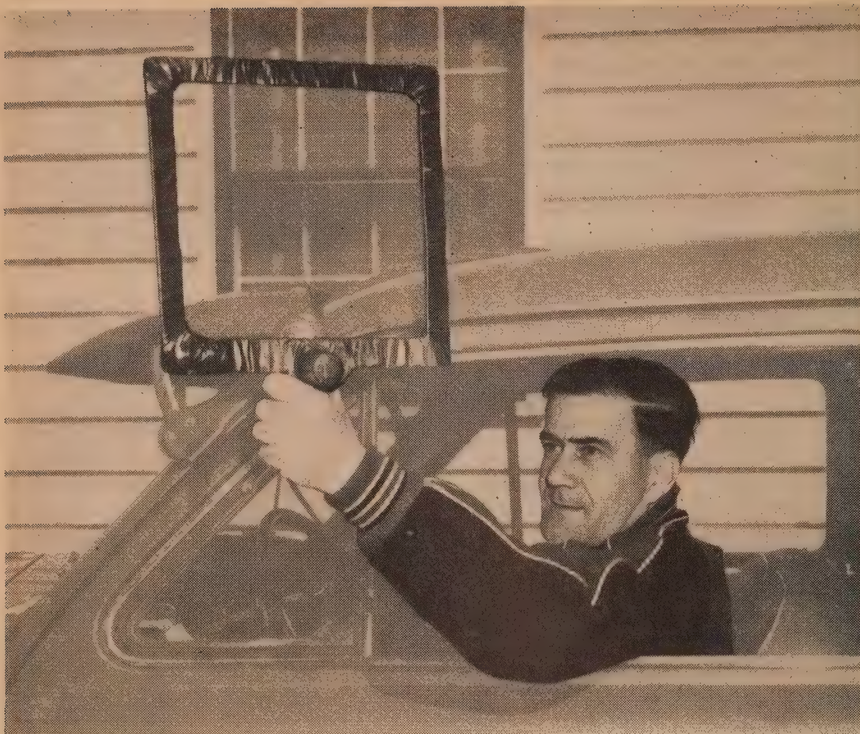


Figure 62.

To date no *simple* way has been found to resolve the 180 degree ambiguity of the loop antenna—it gives no indication which of the two nulls is the correct one. Fortunately we have at disposal a means of quickly determining the approximate direction of arrival of a received signal. Most mobiles have their whips mounted at the rear of the car, resulting in a pronounced gain (2 or 3 *S*-units) on signals arriving from the direction in which the car is facing. The procedure is to drive the car in a circle while watching the *S*-meter. Stop when the strongest signal is being received, and the car will be headed in the approximate direction of the transmitting station.

Attaching the Loop to the Car

Opinion seems to be about equally divided as to whether it is best to hold the loop in your hand when taking bearings or to fasten it to a window-mount as shown in the photographs. If you decide to use a mount for your loop, you probably have your own ideas on how to build it. One method of construction is suggested in *Figure 64*. Exact dimensions and details will have to be tailored to fit your particular car window. The loop is fastened to a two- or three-foot length of aluminum tubing or a broomstick. The main support member may be fashioned from a piece of two-by-four lumber, grooved on each end to conform to the curve of the window, with sponge rubber or felt glued to the ends to protect the car finish. The completed mount is then wedged in the car window opening against the upright partition dividing the main window from the wing. It is held in place by a stiff rod from the center of the two by four to the window guide groove at the opposite side.

The S-Meter

S-meters are a necessity in serious direction-finding work, and they run the gamut from a simple milliammeter lying in the glove compartment to deluxe illuminated jobs permanently fitted into the dashboard ashtray openings.

The simplest satisfactory *S*-meter is a low range milliammeter of about 4 or 5 ma. full scale connected in the receiver between cathode and ground of one or more r-f or i-f stages. A meter connected in this manner will read 'backwards'; that is, with no signal it will read nearly full scale, swinging back toward zero when a signal is tuned in. A forward-reading *S*-meter requires a simple bridge circuit. Either type works well for this application, and full details can be found in any handbook and need not be repeated here. Signal-strength meters are almost universally used in home stations and are being found in more and more mobiles where they are proving to be equally useful.

Now for the Hunt

We're meeting tonight at the fairgrounds where there's plenty of room for all the cars to circle without danger of bumping into each other. Whoever happens to arrive first at the meeting place makes a note of each mobile as

it comes in, the frequencies of any who are not on the net frequency, and eventually gives the list to the hidden transmitter when it comes on the air at 8 o'clock.

Okay, we're all here—the loops are on the cars, tuned up—we're ready to go, and it's every man for himself!

With our rear-mounted whip connected to the receiver, we pull some distance away from the rest of the gang and make a couple of slow circles, keeping an eye on the *S*-meter. We get an *S3* reading when headed south and *S5* when facing north, so we pull out of the south entrance of the grounds (to confuse the others) and head north on the nearest through street.

With our whip tied down and running on the loop, the hidden transmitter's signal is weaker, fading out completely on the null, which now indicates due northeast, being a more accurate check than we got from the broad maximum off the front of the car with the whip.

With the edge of the loop pointed at the station for maximum signal, we get a reading of *S3*, which we make mental note of to check with later readings to make sure the signal will build up in the direction in which we are heading.

Straight north we go—three, four, five miles and the null swings around more and more to an easterly direction; slowly at first, but more rapidly until it bears due east. Turning right at the next crossroad, the loop, of course, shows straight ahead and a glance at the *S*-meter shows a reading of *S7* with the loop oriented for maximum strength, proving that we are drawing steadily closer.

Another minute ticks off and the bearing is changing again, this time to the northeast once more. Abruptly it begins to shift more rapidly and the volume builds up considerably at the

Fig. 64. A view of the type of window mount described in the text. This loop was built into the box from a BC-610 plug in exciter tuning unit. The upright piece of pipe was taken from an old sun-lamp.

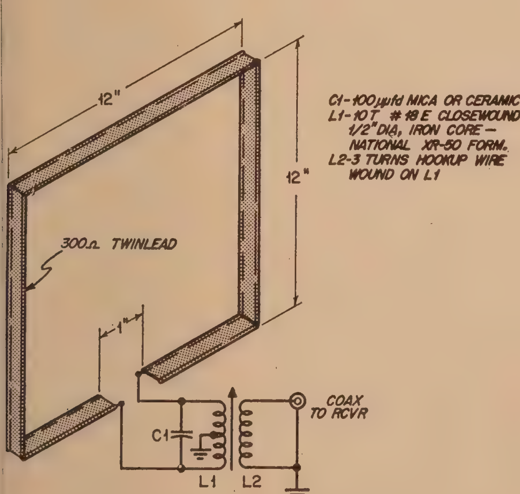


Fig. 63. Schematic of an unshielded loop. The coil must be shielded, and the shield connected to coil center tap, one end of pick-up coil and outside braid of co-ax

same time—shut off the loop filament; we don't need an amplifier now and we might as well save the batteries.

Now we must be careful; we slow down, stopping the car whenever the hidden transmitter stands by, since we want to turn off to our left whenever the loop shows a right angle (due north) bearing again, and we're so close to the hidden transmitter now that we could easily go right by him between transmissions. And wouldn't we be confused by an east-west bearing again!

He's on the air once more; our bearing is due north and there's a barely discernible, little-used road turning off to our left, paralleling the railroad tracks. Up one hill and down another we go, making several turns and bends. The signal is so strong it overloads the loop, making it difficult to get nulls and the twisting road makes it impossible to keep track of the bearings we do manage to get—nothing to do but keep going and maintain a sharp lookout on all sides for possible hiding places. Now what! A sharp bend around a thicket of tall weeds and underbrush, and we're heading right back where we just came from—a deadend loop in the road! No signal from the hidden transmitter, either; he must have caught sight of us and closed down; but where is he? Let's take the flashlight and have a look around. He can't be very far away—he was blocking our receiver during his last transmission. Well, what do you know! There's a car over here be-

hind the thicket we just circled; it's the hidden transmitter all right. He must have driven around the bend keeping just ahead of us with his lights turned off so we couldn't spot him. Well, all's fair in hidden transmitter hunts and we came in first, so we'll be hidden transmitter next week. Know any good spots? Shhh! Not so loud! Let's keep it to ourselves, huh?

Additional Suggestions and Hints

Experience, sometimes bitter, has shown the hidden transmitter should *not* be located (a) on private property, (b) in a boat, (c) on an island, (d) in a cave.

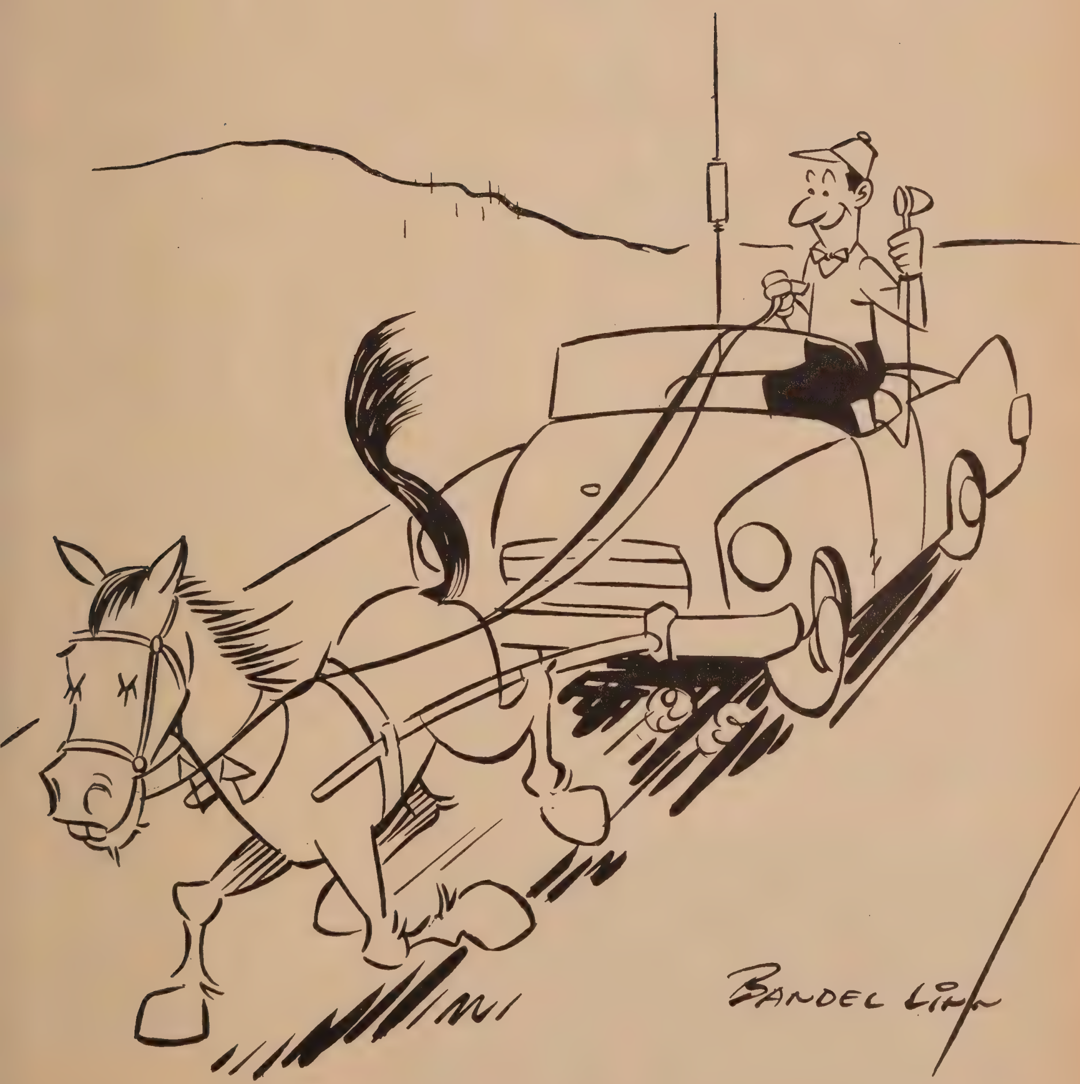
All transmissions by the hidden transmitte should be at least two minutes long to enabl taking of bearings.

Identities of incoming cars should not be dis closed for at least 10 minutes after their ar rival to avoid giving clues to other hunters wh may have seen a praticular car shortly befor and, therefore, know that they must have bee very close to the hidden transmitter at tha location. A vertical antenna should be used b the hidden transmitter since loops do not sho true direction of horizontally polarized waves

And, finally, don't play your hunches—th loop is practically always right!!

Chapter Four

Ignition Noise Problems


BANDEL LINN

Ignition Noise Problems

The automobile, in addition to being a means of transportation, and a container for mobile equipment, is also a prolific source of noise generation. The noise may be generated by the primary and secondary electrical circuits of the car, or it may be generated by static electricity caused by the movement of the car through the atmosphere.

Complete elimination of radio noise cannot be expected as the very nature of the ignition system is such that high frequencies must be produced or else no ignition will result. The high frequency components cannot be eliminated without eliminating or deteriorating the ignition spark itself. Noise reduction, therefore, is noise suppression, rather than noise elimination. It is usually simple enough to suppress noise to a tolerable level, without the rigors of complete electrical shielding, such as used in certain military installations.

The problem of noise can be attacked two ways: The discovery and suppression of the noise at the source, or the addition of a noise limiter to the receiver in the car. The noise limiter is especially valuable in eliminating noise generated by other cars in the immediate vicinity, as well as reducing noise generated by your own car. *Both* methods of attack must be used for a successful mobile installation.

From the noise generating point of view the automotive electrical system may be divided into two parts. First, the generator/regulator system (primary) and second, the ignition (secondary system). Radio noise may emanate from either or both of these systems. A quick test will indicate the guilty system: Run the car at a medium speed with your receiver tuned to the frequency most affected by the noise. Close the throttle and turn off the ignition key allowing the car to coast in gear with the clutch engaged. If the noise stops the trouble is in the generator/regulator system. If the noise continues but with diminished volume, both the ignition and generator/regulator systems are creating noise.

Generator/Regulator System Noise

Generator hash is heard in the form of a low or high pitched whine that varies in tone with the speed of the motor. In order to prevent the power leads from the generator from radiating this hash a 0.1 μfd. coaxial type condenser (*Sprague 80P3*) may be mounted on the dynamotor frame and connected directly in series with the armature lead (*A lead*). Most cars equipped with broadcast receivers have a large paper condenser bypassing the *A* lead. This condenser has too much internal inductance to be effective as a r.f. filter above 2 Mc.,

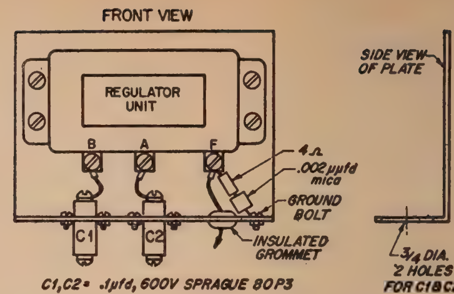


Fig. 1. A decided improvement in mobile noise reduction will result from the use of coaxial capacitors in the leads to the voltage regulator.

so it should be removed and the coaxial condenser substituted for it. In addition, residual noise may be caused by dirty or rough commutator segments or poorly fitting brushes. These should be checked and serviced by a competent generator mechanic.

In certain systems where it is impossible to eliminate the noise with these precautions a trap consisting of a 50 μμfd. condenser in parallel with a coil wound of No. 10 wire and tuned to the operating frequency may be placed in series with the *A* lead at the generator. The trap should be tuned for maximum reduction of noise in the receiver as shown in *Figure 4*.

A smooth sounding noise from the generator is caused by *shaft hash*. This noise is caused by static electricity building up on the rotating shaft of the generator. This shaft is partially insulated to ground by a thin oil film. When the static electricity builds up to a sufficiently high potential to flash through the oil film, it creates radio noise. The shaft may be grounded by mounting a grounding brush to ride on the pulley of the generator. This brush will drain off the accumulating charge on the shaft.

Regulator hash can be identified as a regular crackling noise of even loudness. This type of radio noise shows up generally in the 10, 11 and 15 meter bands. It is caused by sparking at the points of the regulator contacts. It is an intermittent noise as it appears only when the regulator is working. To eliminate this noise, a 0.1 μfd. coaxial condenser should be placed in the battery lead (*B lead*) directly at the regulator, with the case of the condenser grounded to the frame of the regulator. A second 0.1 μfd. coaxial condenser should be put in the armature lead (*A lead*) directly at the regulator. Its case, also, should be well grounded. The remaining lead is the field lead (*F*). This cannot be bypassed as the other leads without damage to the regulator. However, a 0.002 μfd. mica condenser in series with a 4-ohm 1-watt carbon resistor from *F* lead to ground will suppress the noise in this lead. *Figure 1* shows a complete regulator installation. The various filters are mounted to an "L" shaped metal plate bolted to the base of the regulator.

For stubborn cases, the regulator may be disconnected from the circuits by a switch in the *F* lead, and a 30-ohm 25-watt potentiometer connected from the generator field to ground to manually control the charging rate of the battery. However, such a drastic step as this is seldom required.

Ignition Noise

Having disposed of the noise from the generator/regulator system, we will now examine the secondary electrical system of the car: the ignition system. *Figure 3* shows a typical ignition system complete with suppression devices.

Wiring: The high voltage ignition wiring is often a source of noise radiation in itself. The metal connecting caps on the ends of the ignition leads are usually crimped onto the wire ends. This results in a poor electrical connection at these points with the possibility of noise generation. These caps should be removed, cleaned and soldered to the wire conductor. The cables should be wiped clean of grease and dust and inspected for break downs or cracks in the insulating material. Fibre spacers may be made to hold the cables away from each other and from the motor itself.

Ignition Coil: The coil, even though in a metal can, frequently radiates considerable noise. A piece of strip brass soldered to the can and securely grounded to the car frame at the opposite end will help. A 0.1 μfd. coaxial condenser should be mounted on the car frame and the primary lead from the coil run through this condenser to the primary ignition circuit.

Distributor: The distributor, as the name implies, correctly distributes the firing spark to the proper plug at the proper time. It is a high voltage rotary switch, cam driven by the automobile engine. When the rotor electrode is positioned near a stator terminal in the distributor, the air gap breaks down and a conducting arc is established. The establishment of this arc, combined with the abrupt drop in secondary voltage, generates considerable radio noise.

A 10,000 ohm suppressor (*Erie L7VR-10ME*) in the center distributor arm lead and 5000 ohm suppressors (*Erie L7VR-5ME*) in each spark plug lead at the distributor will effectively suppress the noise from this source. Be sure these suppressors make good electrical connections to the lead wires.

Spark Plugs: The spark plug potential varies rapidly between some 8000 volts unfired and 1500 volts when fired. These rapid changes generate a tremendous amount of radio noise, heard as a popping sound running in step with the speed of the car motor. A 10,000 ohm suppressor located at each plug is necessary to reduce this source of noise. In general, three methods may be used to introduce this suppression into the circuit: 1) The use of suppressors, as mentioned above. 2) The use of suppressor- or resistor-type spark plugs. 3) The use of resistive ignition cables. Satisfactory results may be obtained by using one or more of these methods. The motor timing should be readjusted after the insertion of the suppressors.

Other Noise Sources

Instruments: The gas gauge, heat gauge, oil gauge and certain other instruments can produce a considerable radio noise level in the car. The most practical way to determine this after the primary and secondary electrical circuit noise has been reduced is to disconnect all the "hot" leads to the gauges. With the receiver gain turned up, the leads are replaced one by one while listening for a change in the noise level. The gauge noise usually takes the form of a periodical, rasping sound. Most of this can be eliminated by installing a coaxial 0.1 μfd. condenser at the position where the gauge is mounted, and grounding the condenser case to the frame of the car. It may also be necessary to provide another condenser at the proper instrument terminals on the dashboard of the car.

Wheel Static: This noise shows up as a steady popping sound at medium or high speeds on dry roads. It is more noticeable on some surfaces than others. As in the case of the generator, it is caused by static electricity building up on the wheels, which are insulated from the car by a thin film of grease in the axles. When this film of grease breaks down and allows the electrical charge to flow to ground, the popping noise is produced. Static collectors may be bought from a car dealer and placed inside the front wheel hub caps. These effectively ground the wheel to the axle and prevent the accu-

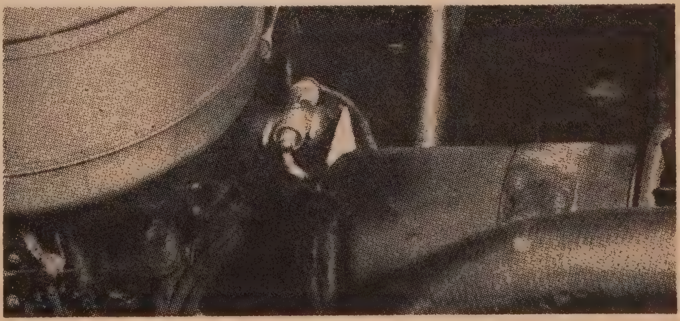


Fig. 2. Generator hash in the Ham bands may be reduced by replacing the paper capacitor across the generator with a coaxial type. This mounting shows a Sprague 48P9.

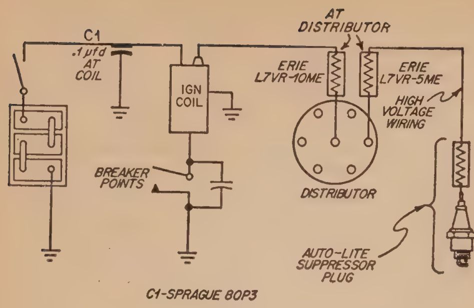


Fig. 3. This is a typical ignition system with suppression devices at every trouble spot.

mulation of wheel static. Rear wheel static collectors may also be purchased on special order through your local automobile dealer.

Tire Static: Some tires create a radio noise that is generated between the inner tube and the inside casing of the tire. This may be eliminated by injecting a special anti-static powder into the tire through the air valve. The powder and injector may be obtained through some dealers, although it does not seem to be a universally stocked item.

Imperfect Bonding: Certain parts of the automobile are either ungrounded, or have an imperfect ground path to the chassis of the car. The exhaust pipe and muffler should be bonded to the frame of the car at several points by a short, flexible braid. The engine block and firewall should both be bonded to the car frame. The steering column, control leads, choke, and temperature indicator leads should be bonded (or bypassed with coaxial condensers) where they pass through the firewall. This will prevent these leads from conducting radio noise into the interior of the car. Attention should be given to any lead that passes through an insulated opening in the firewall into the interior of the car.

Antenna Installation Precautions: The transmission line from the receiver to the antenna must be bonded to the frame of the car at the antenna end, and bonded to the receiver chassis at the receiver end. The receiver chassis should be grounded to the car frame with as low resistance a ground connection as can be made. This should, if possible, be a separate ground from the one that supplies power to the re-

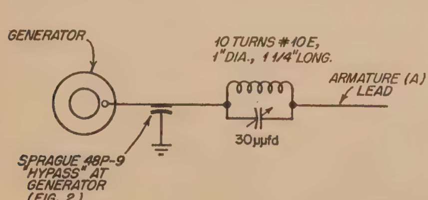


Fig. 4. Tuned trap to reduce generator noise on the 10 meter band.

ceiver. If the antenna is of the usual whip design, it may be noticed that at high speeds on dry pavements a high pitched whine may be heard in the receiver. This is known as *velocity static* created by the metal area of the car picking up static charges. Since the antenna is the highest point on the car, it will discharge this static and create the high pitched noise. Some antennas have a plastic ball on the tip to stop this effect. If this is missing, a short length of cambric tubing slipped over the tip of the antenna will do the job. Seal the top end of the tubing with Duco cement or nail polish and wrap it with friction tape to hold it in place. The cambric tubing will slowly discharge the velocity static at a rate that cannot be heard in the receiver.

Ignition Noise in 12-volt Systems

Suppression of noise in 12-volt automotive ignition systems is, in general, similar to the procedure outlined for the more common 6-volt systems. It must be remembered, however, that the noise generated by the ignition system is proportional to the square of the system voltage. Doubling the voltage from 6- to 12-volts produces a noise increase of four times. Modifications that would reduce the noise to a nominal level in a 6-volt system may therefore be marginal when applied to the same degree to a 12-volt installation. Additional suppression, shielding and bonding are therefore needed to reduce the noise level to that experienced with a 6-volt system. Some noise suppression ideas that have helped materially with 12-volt ignition noise are:

1—Connect the auto receiver and converter directly to the "hot" battery terminal, bypassing the electrical system of the car. This will eliminate most noises introduced to the receiver through common coupling in the A-lead. The worst place to obtain primary power for the car radio and converter is from the ignition switch, as this is a prolific source of noise. In some instances, shielding the A-lead to the converter and radio helps greatly in reducing primary pick-up noise.

2—Test your battery. A good, well-charged heavy-duty battery provides a low impedance short across the noise system of the car, acting as sort of a noise filter. An old battery, having high internal resistance contributes very little towards noise suppression.

3—On ten and fifteen meters, a tuned wave trap placed in the generator lead (*at the generator*) usually helps. (*Figure 4*) Mount the trap to a piece of insulating material and fasten it to the generator. Start the motor, and tune the trap for minimum generator whine heard in the receiver.

4—Shield the lead from the generator to the voltage regulator, securely grounding

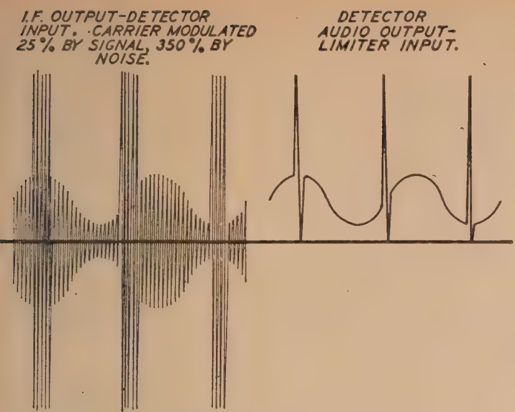


Fig. 5. A duration/amplitude comparison of noise pulses vs. desired signal modulation.

both ends of the braid. RG-59/U coaxial line may be used for this lead. Shield the lead from the ignition switch to the firewall, grounding both ends of the shield braid.

5—If excessive noise persists, make up a coaxial lead to fit the antenna connection of the converter. Place a two inch probe on the free end of the inner conductor. By moving the probe about over the ignition system and listening to the noise level in the receiver, the "hot spots" generating the noise may be located.

6—If excessive noise occurs at night, check all headlamp connections.

7—Be sure the exhause pipe is firmly bonded to the frame of the car at both ends. The exhaust pipe can act as a "waveguide", conduction ignition noise from the motor back to a whip antenna mounted on the rear of the car.

8—Check the generator brushes. If excessive sparking is noticed, sand the armature with 00 sandpaper, as the mica separator strips may be too high for the brushes to seat properly.

Noise Limiters

The job of noise suppression described in the first part of this chapter can be completed through the addition of a noise limiter to the automobile receiver. This is the only way to suppress noise generated by cars other than your own!

Noise reduction circuits have been developed for application at any one of several places in a receiver. Of all these circuits, one of the most efficient and simple is the type employing one or two diodes (half wave or full wave) connected in series or shunt with the audio connection between the second detector and the first audio stage of the receiver.

The Nature of Noise Interference

The most common types of noise plaguing the mobile operator are the pulse noises such as car ignition, atmospheric noises and spark discharges. Compared to the length of a cycle at usual speech frequencies the noise pulses are usually of short duration and spaced widely apart (*Figure 5*). The reason that these pulses blank out so much of the wanted signal in spite of the fact that sometimes several cycles of the signal may appear between noise pulses, is that the pulse amplitude of the noise is usually so much greater than the desired signal level that when the pulse hits the receiver the speaker vibrates much longer than the duration of the noise pulse. While the human ear can easily separate a coherent signal from noise, it seems to have a "built-in" a-v-c system which automatically desensitizes the ear from the noise. This action of the ear, combined with the acoustical characteristics of present day reproducers tends to fill in the gaps between noise pulses to such a degree that most, if not all, of the desired intelligence may be lost.

The receiver i-f amplifier will also lengthen the duration of the noise pulse; the exact amount of lengthening depending upon the i-f bandwidth. High Q circuits will "ring" or continue to oscillate beyond the actual duration of the pulse, a narrow bandwidth causing greater ringing action than a broad bandwidth. This action of the i-f amplifier would indicate the

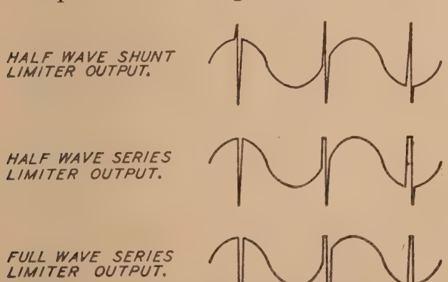


Fig. 6. To recover the intelligence in the signal the most common types of noise limiters restrict the pulse amplitude. The relative efficiency of the three basic types is shown above.

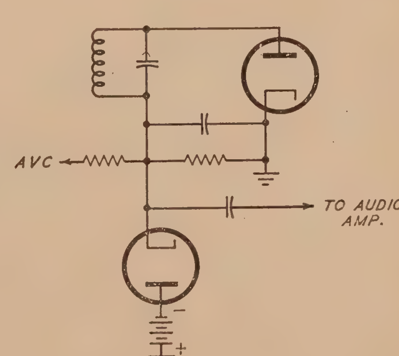


Fig. 7. The simplest type of noise limiter places a diode in shunt across the audio output of the second detector.

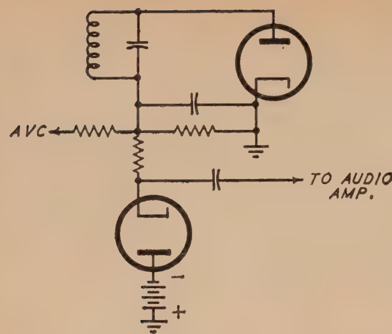


Fig. 8. A common practice when using diodes in the shunt limiters is to insert a resistance between the detector and the limiter. This reduces the effect of the internal resistance of the diode upon the limiting action.

desirability of applying noise limiting principles to the i-f section of the receiver before the pulses can be lengthened. Some circuits have been devised for this purpose. Fortunately most noise trains have sufficient space between individual pulses that by the time they reach the second detector the simple limiter circuits can do a good job. All that needs to be done is to limit the noise pulses in amplitude to a level near that of the desired signal so that most of the intelligence between the noise pulses can be recovered (*Figure 6*). The three types of circuits illustrated herein offer the most effective action for the least complicated circuitry.

The Simple Shunt Limiter

The short circuit type of noise limiter known as a *Shunt limiter* is a diode in series with d-c bias connected in shunt across the audio output of the second detector of the receiver (*Figure 7*). The polarity of the diode and bias is so arranged that the diode will not conduct until signal or noise voltages exceed the bias level. When the bias level is exceeded, the diode conducts and acts as a low resistance path to ground for the excessive voltage. Since the usual diode is not a "perfect" diode, but contains internal resistance, a resistor is connected in series between the detector output and the limiter so that the combination of the two resistances will not act as a voltage divider. This is necessary to step down the amount of noise voltage passed on to the audio circuit when the imperfect diode conducts. While it reduces the audio voltage, its effect on reducing the noise pulses exceeding the bias level is proportionately much greater (*Figure 8*).

This circuit is capable of doing the job on a steady signal where the bias can be set to barely let the audio peaks go by untouched but clips all the noise pulses down to about the same value. However, most signals fade up and down so rapidly that it would be impossible to follow the signal level with a manual bias control. Thus a bias setting for a weak signal would severely clip the audio of a strong signal; however, the bias setting could be taken care of automatically by the same source from which the receiver a-v-c bias is obtained. This provides a d-c bias which is determined by the carrier level, and by adjusting the proportion of audio voltage and automatic bias applied to the limiter from the second detector, the limiter can be designed to clip all voltages above a predetermined percentage of modulation. By making one of the resistors of the circuit a potentiometer instead of a fixed resistor, a certain percentage of modulation may be chosen at which limiting will begin, and the limiter will automatically clip at this level no matter how much the signal is fading.

For those who prefer extreme simplicity, a fixed percentage of clipping can be quite satisfactory. The clipping level may be set as low as 30%-40% modulation before audio distortion becomes objectionable. If the *average* modulation level is much higher than this, the noise limiter must be set at a correspondingly higher clipping level to prevent severe audio distortion. The reason for setting the limiter to the lower average percentage of modulation rather than at the 100% value is so that it can bring all the noise peaks down close to the average audio signal level.

Figure 9 shows a shunt limiter suitable for connection between a diode second detector and the first audio amplifier grid. *R1* and *R2* make up the detector load resistor and should total about the same as the value presently in the receiver to be modified. The usual value is about 500,000 ohms. *R4* and *C1* provide the automatic bias for the diode. *R3* is the series dropping resistor which provides the voltage divider action previously mentioned. The value

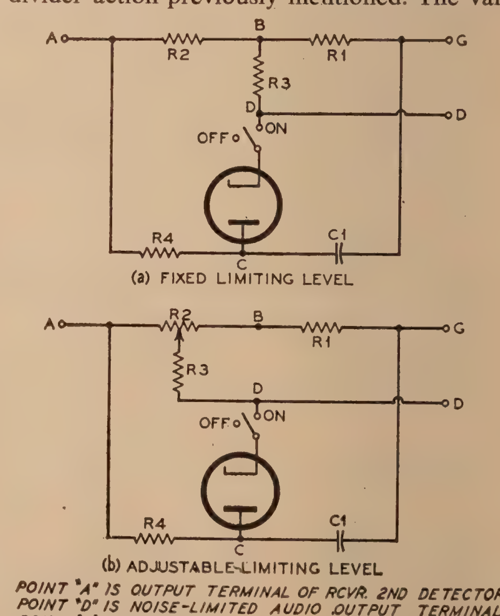


Fig. 9. These are two of the most commonly employed shunt type noise limiters.

R_3 = 500k	C_1 = 0.05 uf	R_4 = 1.0 Meg	
% limiting	R_2/R_1	R_2	R_1
100%	1/1	250k	250k
50%	1/2	166k	333k
40%	2/5	140k	360k
30%	1/3	125k	375k
0-100%	1/1	250k pot.	250k

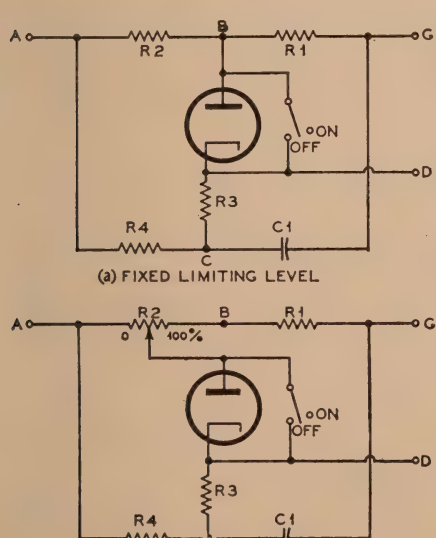
Table 10.

of *R3* should be about equal to the value of the grid resistor of the audio amplifier to which the noise limiter output is connected. This is usually 500,000 ohms. An audio coupling condenser should be used between the limiter and the volume control or audio grid lead to prevent d-c voltage from reaching the audio grid.

The ratio of *R2/R1* determines the percentage of modulation at which the clipping action takes place. A ratio of 1:1 will cause the diode to clip at approximately 100% modulation. Where a variable modulation clipping control is not used, a clipping level of 40% is recommended. *Table 10* shows typical values for *R1* and *R2* for various levels of clipping.

A Simple Series Limiter

The *series or open circuit limiter* depends on the limiter diode conducting at normal signal levels and opening on high modulation amplitudes or noise peaks. Since the diode is in series with the audio path, this action will effectively clip the noise peaks. *Figure 11* is a representative half-wave series limiter circuit. A germanium crystal diode is not suited as a series limiter since the back resistance of the diode is too low, whereas a vacuum tube diode will cut off all voltages above the clipping level.



(a) FIXED LIMITING LEVEL

(b) ADJUSTABLE LIMITING LEVEL

Fig. 11. These are representative half-wave series type noise limiters.

Table 12 contains typical circuit values for a series circuit.

In the series limiter the values of all resistors *R1*, *R2*, *R3* and *R4* have an effect on the threshold level. Where *R3* equals *R4*, *R3* plus *R4* in parallel with *R2* should equal *R1* for 50% limiting, and should equal twice *R1* for a limiting level of 100%. If a limiter is to be connected to a detector having a 500,000 ohm load, the sum of all the conducting branches of the limiter and the new load resistor should equal 500,000 ohms. If it is desired to make the clipping level adjustable, *R2* can be made a potentiometer. Zero to 100% modulation level of positive peak clipping can be selected as the arm of *R2* is moved from *point A* to *point B*. As in the shunt limiter, if two diodes are available for use in the half-wave series limiter they should be connected in parallel. This will lower the effective internal resistance

C_1 = 0.05 uf	R_3 = 500k	R_4 = 1.0 Meg	
% limiting	$(R_3+R_4 \parallel R_2)/R_1$	R_2	R_1
100%	3/1	500k	125k
50%	3/2	475k	200k
40%	6/5	375k	225k
30%	1/1	300k	250k
0-100%	3/1	500k pot.	125k
C_1 = 0.05 uf	R_3, R_4 = 1.0 Meg		
% limiting	$(R_3+R_4 \parallel R_2)/R_1$	R_2	R_1
100%	2/1	400k	166k
50%	1/1	285k	250k
40%	4/5	250k	275k
30%	3/5	220k	310k
0-100%	2/1	400k pot.	166k

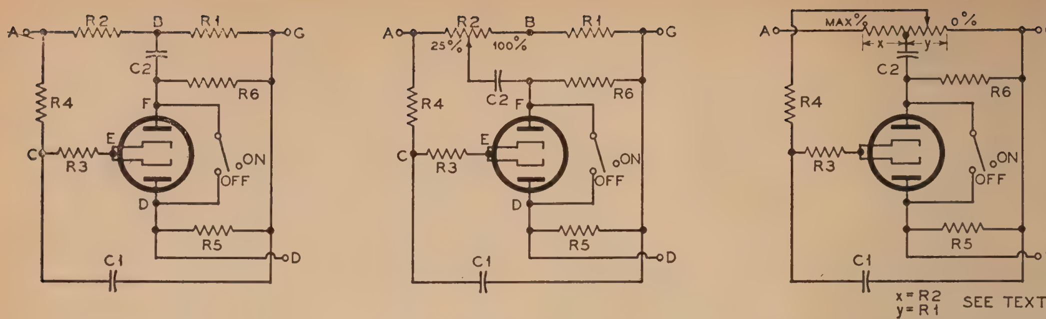
Table 12.

and permit higher audio output as well as a more nearly constant clipping level.

The half wave clipper clips at not less than 100% on negative peaks, regardless of the clipping level on positive peaks. A full wave clipper will provide equal clipping of both positive and negative peaks.

The Full Wave Noise Limiter

The full wave noise limiter circuit that affords the best limiting action with the fewest parts are the series diodes (*Figure 13*). The diodes are arranged so that with any d-c output voltage from the detector both sections will be conducting. The audio voltage will then be coupled to the audio amplifier through *C2* and the two diodes. On peaks causing large negative voltages at *point B*, diode *E-F* will cut off, and on peaks tending to reduce the carrier to zero, diode *D-E* will cut off. To obtain symmetrical clipping *R5* and *R6* should be twice the value of *R3*. See *Table 14* for full wave series circuit values. if *R2* is a potentiometer with *C2* connected to the arm, a clipping level between 100% and 30% can be selected, maximum audio output being secured at the most useful clipping levels in the region of 30-50%.



(a) FIXED LIMITING LEVEL (b) ADJUSTABLE LIMITING LEVEL LIMITED MINIMUM RANGE (c) ADJUSTABLE LIMITING LEVEL RANGE 0 TO SELECTED MAXIMUM

Fig. 13. These circuits are variations of the full-wave series type noise limiter.

Connecting the Noise Limiter to the Receiver

Incorporating any of the limiter circuits described into a conventional automobile receiver is relatively easy. The circuits of *Figure 15* are representative of the more common second detector circuits. Dotted lines are shown for the connections to be removed before insertion of the limiter. The existing detector load resistor should be removed. Insert the limiter circuit chosen with *points A*, *G* and *D* of the limiter circuit connected to the corresponding lettered points. Long leads in the audio path should be avoided if possible, otherwise shielded wire should be used. For the series limiter circuits care should be taken to keep down any possible capacity coupling between the input and output circuits of the limiter. The leads to the *on-off* switch should be as short as possible and should be kept apart. The a-v-c circuit for the receiver should be left undisturbed if at all possible. The connection of the limiter at *point G* into the detector circuit should be to the same point as that of the detector load resistance before modification, even though it may not be at the ground potential. (For example, certain delayed a-v-c circuits.)

Additional Notes

1. The values of the resistors and condensers in *Tables 10*, *12* and *14* are for second detectors having a 500,000 ohm load resistor before modification. For detector circuits having a substantially different load resistance, the resistor values must be changed by the ratio of the load resistance to 500,000 ohms. Thus, if the detector has a load resistance of 200,000 ohms, each resistance value in the above figures should be multiplied by 2/5. *C1* should be then increased by a ratio of 5/2. *C2* may remain the value given in the table as it is not critical as to capacity.
2. For proper operation of a limiter of any type, the i-f signal level should be high enough to overcome the emission potential of the diode tube. Many times better limiting action can be obtained by reducing the filament voltage of the diode tube.
3. It has been the experience of most hams that a 6AL5 makes a better limiting tube than a 6H6 and that either one of them is better than a crystal.

A Simple Series Limiter

Five resistors, two condensers, a switch and a 6AL5 tube make up a simple but very effective noise limiter. This unit may be built in a small aluminium box measuring 2 3/4" deep, 2 1/8" wide and 1 5/8" high (*Bud CU-3000*). The 6AL5 is mounted on the rear of the box, and the "on-off" switch on the front. A tube shield should be placed over the 6AL5 tube. The complete circuit of the limiter is shown in *Figure 16*. Connections to the limiter are made through four shielded leads. Lead A is the input to the limiter, and connects to the second detector circuit of the automobile receiver as shown in *Figure 15*. If a decoupling circuit (R-C) is found in the auto receiver, the decoupling resistor should be shunted with a 22,000 ohm, ½ watt resistor, and the condenser, *C*, should be removed. In some radios,

C_1 = 0.1 uf C_2 = 0.02 uf R_3, R_4 = 500k R_5, R_6 = 1.0 Meg			
% limiting	R_2/R_1	R_2	R_1
100%	2/1	500k	250k
50%	1/2	250k	500k
40%	1/5	125k	625k
33%	---	0	750k
33-100%	2/1	500k pot.	250k
C_1 = 0.05 uf C_2 = 0.02 uf R_3 = 500k R_4, R_5, R_6 = 1.0 Meg			
% limiting	R_2/R_1	R_2	R_1
100%	3/1	5ook	166k
50%	1/1	333k	333k
40%	3/5	250k	415k
25%	---	0	660k
25-100%	3/1	500k pot.	166k

Table 14.

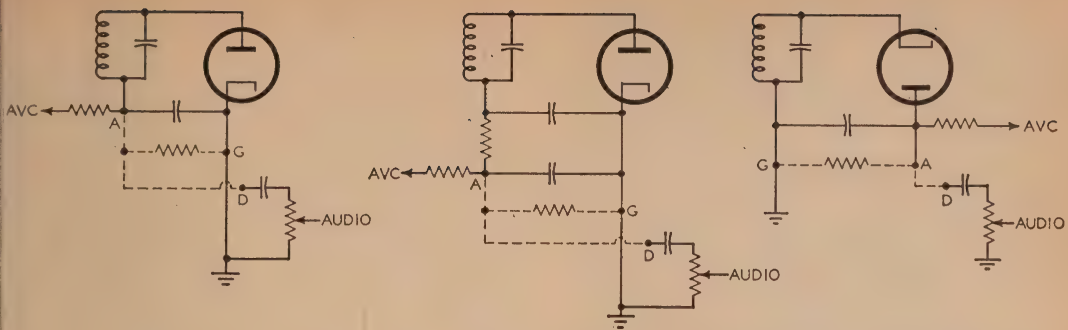


Fig 15. Shown above are three of the most common types of second detector circuits. Points A, D and G correspond to similar junctions in Figs. 8, 9, 11, and 13. Any one of those circuits may be inserted in the second detector by removing the load resistor shown in the dashed lines.

hese components are located inside the last -f transformer can.

The diode load resistor is next removed, as shown in *Figure 15* and lead G from the noise imiter connects to *point G* in the auto receiver. In some sets *point G* may be ground, and in others it may be a cathode resistor network. In any event, *point G* is at the "bottom end" of the diode load resistor.

Lead D of the noise limiter goes to the "hot" end of the volume control. Since an audio coupling condenser is incorporated in the noise limiter, the one that is in the set may be removed, or the two may be connected in series.

The filament lead of the noise limiter should connect to a 6-volt filament lead in the auto receiver. It will be noted that the filament voltage to the 6AL5 is dropped in value by a 5-ohm resistor in the noise limiter. This resistor decouples the 6AL5 from noise that may be introduced into the limiter circuit via heater-cathode leakage. If the limiter is to be used in a car having a 12-volt ignition system, the filament resistor of the 6AL5 should be increased to 10-ohms, 1-watt.

The leads from the clipper to the receiver are made of short lengths of shielded wire. Care must be taken to ground the loom of the shield at each end of the wire. Keep these leads away from the receiver vibrator to prevent any hash pickup from this component. To prevent the shields from shorting to receiver components inside of the receiver chassis, the leads should be wrapped with tape.

the TNS Limiter

Until the development of the TNS Limiter (Twin Noise Squelch) the full wave series limiter was found to be superior to other types of limiters. Results in limiting noise pulses when receiving a signal were quite satisfactory, but during standby receiving periods, or while tuning around the band for signals, the residual background noise produced by the clipped noise pulses of the series limiter is very high.

The TNS (*Figure 17*) is a very effective noise limiter. Under severe highway noise conditions, the TNS performs better than the full-wave series limiter in regards to audio-to-background noise ratio, and intelligibility. Under bad noise conditions the squelching action of the TNS not only eliminates the tiring background grind, but it also enables the operator to easily find a weak signal. With the usual type of noise limiter even a moderately strong carrier is sometimes hard to find in the background noise, unless the carrier has modulation on it. With proper setting of the TNS extremely high level ignition pulses from busses and

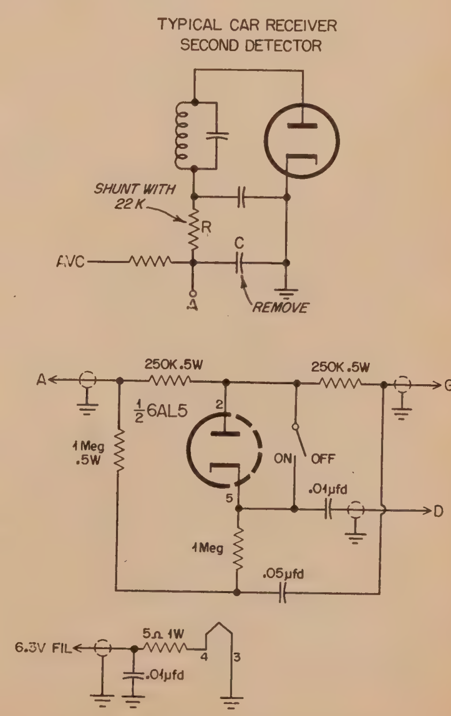


Fig. 16. Simple mobile noise limiter.

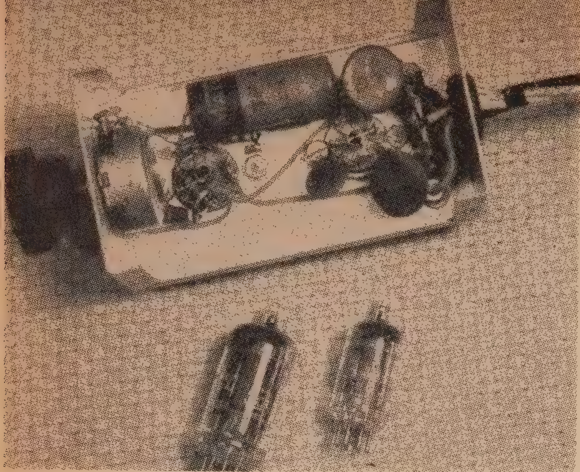


Fig. 17. Construction of the TNS is simplicity in itself. This unit provides squelch action as well as noise silencing properties to improve mobile reception.

trucks are eliminated, something that is almost impossible to do with the usual noise limiter.

Operation of the TNS

In operation, both grids of the dual triode tube (*V1*) receive bias variations at the rate of the audio frequency (*Figure 18*). The plate current of section B of *V1* varies at the audio rate and is coupled to the cathode of section B of the limiter tube *V2*. The plate current of section A of *V1* varies at an *average* rate due to filter components *C1*, *C2* and *R2-R3*. The plate loading resistors *R6* and *R7* are chosen so that with no audio excitation from the detector, the positive voltage on the plate of section A of *V2* is slightly higher than the positive voltage on the cathode of section B of *V2* resulting in a current flow through the limiter tube. Since the plate of section B of *V1* is coupled to the cathode section of B of *V2* an audio signal is obtained from the output of the limiter tube, *V2*. If a noise impulse with a steep wave front is received, the grid of section B of *V1* will be driven more negative which will cause a rise in plate voltage in section B of *V1*. The cathode of section B of *V1* is driven more positive than the plate of section A of *V2* and the current flow through the limiter tube is interrupted, causing a hole to be punched in the signal. While the grid of section A of *V1* receives the same impulse as the grid of section B, the plate of section A does not follow the noise impulse due to the time constant of the filter components *C1*, *C2* and *R2-R3*. Therefore the plate of section A of limiter tube *V2* does not receive the noise impulse in phase with the cathode of section B of *V2*. However, the noise impulse is coupled to the plate of section A through resistor *R2* and capacitor *C1* and arrives out of phase, which tends to lower the positive plate potential, thus aiding in reversing the polarity between the plate of section A and the cathode of section B of limiter tube *V2*.

Since the plate potential of section A of *V1* varies at an average rate directly proportional to the strength of the incoming signal, the noise limiter threshold is automatically set, and the limiter is effective on all values of modulation.

Adjustment of the variable resistor *R7* will provide a squelch action which is very effective in the suppression of the background noise.

Audio output is taken from the plate of section B and the cathode of section A of *V2*. Automatic volume control is obtained from the second diode of the detector tube.

Construction of the TNS

The TNS may be built directly into the new equipment. However, the greatest interest will be in an auxiliary unit that may be connected to an existing receiver.

The TNS unit consists of two tubes, a 6AL5 diode (*V2*) and a 12 AX7 double triode (*V1*). Since these tubes are operating in a high impedence circuit, the input and output leads (A and D) between the TNS and the receiver must be made of shielded cable, such as *Belden 8885*. A filament, ground, cathode return (G) and B plus lead must also be run to the TNS, making a total of six leads, two of them shielded. The shields may be used as the ground return of the unit.

The TNS may easily be built in a small metal box measuring 2¼″ x 2¼″ x 4″. (*Bud CU-3003*) A *Vector 8-N-9T* turret socket should be used for the 12AX7 as most of the resistors and condensers may be mounted directly on the terminal lugs (*Figure 20*). Since

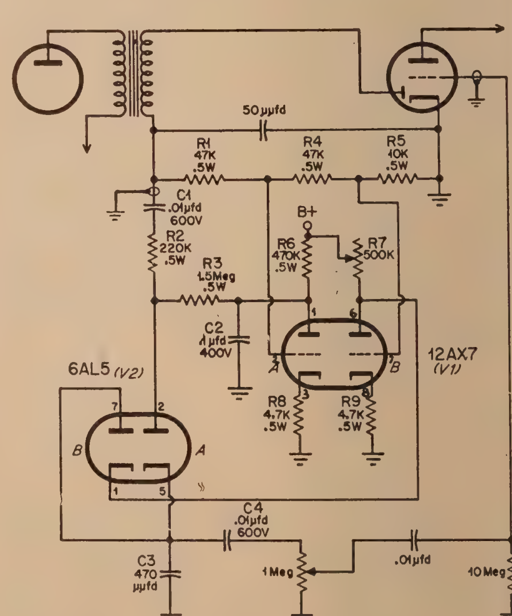
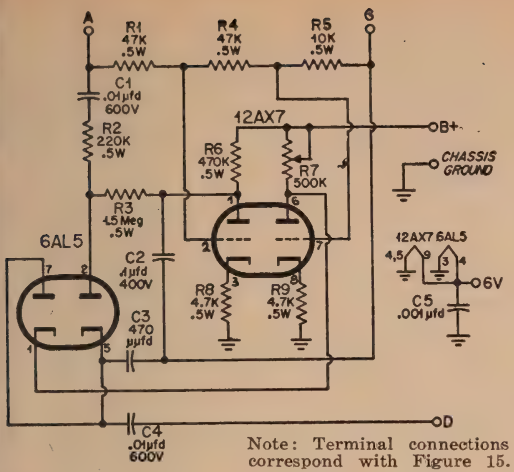


Fig. 18. Basic TNS circuit.



Note: Terminal connections correspond with Figure 15.

R1, R4—47,000 ohms, ½w.	R8, R9—4700 ohms, ½w.
R2—220,000 ohms, ½w.	C1, C4—0.01 µfd., 600v.
R3—1.5 megohm, ½w.	C2—0.1 µfd., 400v.
R5—10,000 ohms, ½w.	C3—470 µµfd.
R6—470,000 ohms, ½w.	C5—0.001 µfd.
R7—500,000-ohm potentiometer	

Fig. 19. This is the TNS adapter unit which is designed to work with any automobile radio. The points A, D and G correspond to those shown in Fig. 15.

he TNS is left in the circuit continually, the only control on the box is *R7*, the squelch level control. This is mounted on the small end of the box, and the two tube sockets are mounted on the 2¼" x 4" side. A Cinch-Jones socket (*P306-FP*) is mounted on the opposite end of the box from the squelch control and the six connecting leads are run through this plug and socket. The cable leads A and D which run from this plug must be made of shielded wire.

Installation of the TNS

The TNS may be adapted to any conventional receiver by referring to *Figure 15*. This illustrates the more common detector circuits encountered in auto radios. Dotted lines are shown for the connections to be removed before insertion of the TNS. The existing load resistor should be removed, as shown. Insert the TNS, connecting the corresponding points of *Figure 19* and *Figure 15* together. Point *G* of *Figure 19* should be connected at the cathode terminal of the diode socket (the connection point of the old load resistor) even though this point may not be at ground potential, as in the case of certain delayed a-v-c circuits.

Leads *A* and *D* should be each individually shielded throughout the cable run from the TNS to the receiver, as well as inside the receiver.

Best operation of the TNS is obtained when separate detector and audio tubes are used in the auto radio. When a diode-triode tube is used for both functions (such as a 6SQ7 or a 6AV6) there may be signal leakage through the common cathode of the tube, resulting in strong ignition pulses leaking through the limiter. The best detector-audio circuit tried with the TNS used a dual diode as detector and a.v.c., and a separate triode tube as the first audio stage (*Figure 21*). A 6AL5 is used as the diode tube, and a 6AV6 or 6AT6 is used for the audio stage.

Notes on the TNS

The TNS should be connected to the auto radio, and the squelch action applied by advancing the squelch control until all normal background noise just disappears, leaving no sound in the loudspeaker. Tune around the band until a carrier is found, upon which the squelch will automatically trigger, and the audio component of the signal will be heard in the speaker. Cessation of the carrier will immediately put the squelch in operation and silence the speaker. By backing off on the squelch control to where it rests at a critical level where only light background noise is barely heard, a weak carrier will trigger the

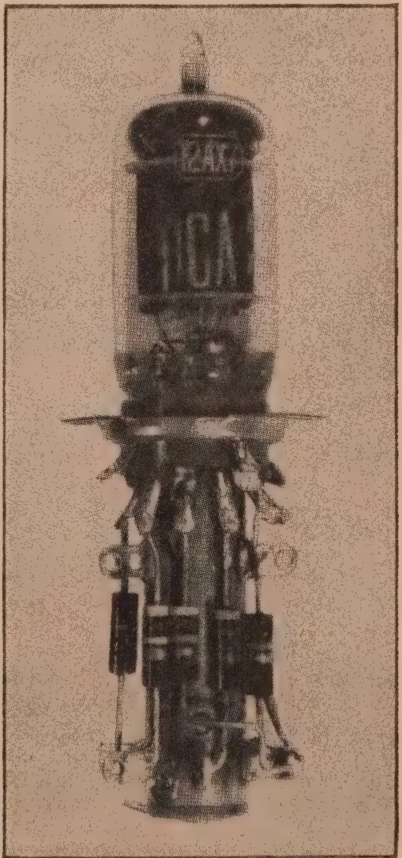


Fig. 20. In this adapter the major portion of components were mounted on a Vector socket

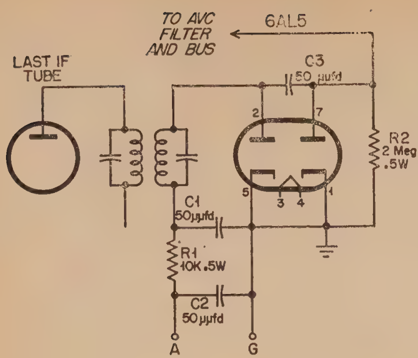


Fig. 21. This is the recommended second detector and first audio modification in the car receiver to obtain optimum results with the TNS.

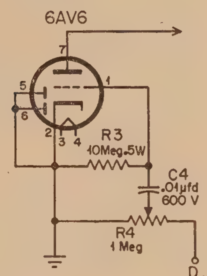


Figure 21.

squelch permitting the audio to be heard.

Under severe noise conditions the TNS not only eliminates the background grind, but it also enables one to easily find even a weak carrier—it just pops up out of the background!

As with other noise limiters, the TNS requires a fairly high i-f signal level at the detector, and the performance of the noise limiter system will be impaired if the receiver has low gain in the r-f and i-f circuits.

On the other hand, too high a level from the r-f converter will cause overloading on heavy ignition impulses, and the ratio of ignition to r-f signal level will not be handled properly by the a-v-c system.

How to Adapt Your Receiver for the TNS

The first stumbling block that many potential users of the TNS encounter is the problem of how to adapt the TNS to an existing receiver. A number of auto radio detector circuits are shown in *Figures 22, 23, 24* and *25*. The input to the audio section of the receiver is marked *to a-f grid*. Resistor *Ra* is the usual a-v-c filtering resistor.

Before the TNS can be used with any of these circuits, the wiring shown as dashed lines must be disconnected. Points labelled A, D and G are then connected to the corresponding points on the TNS (see schematic, *Figure 19*). The connecting leads for points A (input) and D (output) must be individually shielded.

The load resistor, *RL*, in *Figs. 22, 23* and *24*, is replaced by the network consisting of *R5, R6* and *R7*. The point to keep in mind when installing the TNS is that these resistors must always take the place of the fixed value load resistor in the unmodified receiver. The output point, *D*, of the TNS must be connected to the input side of the volume control feeding the first audio stage. This is labelled point *D*, in all diagrams.

There is a "hot" ground lead, *G*, from the TNS unit. Do not connect the heater grounds through this lead. It must be connected directly to the diode cathode terminal to minimize possible ignition noise pickup from your own car. This would be due to the varying ground potential which might result if the ground were carried through the metallic chassis, or other ground leads.

Figure 22 is a fairly common example of the a.v.c. and second detector circuit. *Figure 23* differs from *Fig. 22* through the addition of an r-f filter composed of *Rf* and *Cf*. The condenser, *Cf*, will usually run to a value of 100 µµfd. and may be in the i-f transformer can. Resistor, *Rf*, will be between 10,000 and 50,000 ohms. If a value higher than this is encountered, it should be shunted by another resistor to bring it within the above range. If the value is too high there will be a loss of audio.

In *Fig. 25* the load resistor of the circuit originally consisted of the volume control, *RL*. When the TNS is installed it will continue to perform as the volume control. In the case of delayed a.v.c., shown in *Fig. 16*, the "hot" ground, *G*, of the TNS is connected at point *G* (*Fig. 26*) where the load resistor (volume control) is connected, even though this point is above ground by an amount equal to the delay bias resistor, *Rb*.

Checking Through Your Receiver Circuit

Probably the easiest way to check the auto radio schematic is to start with the lead connected to the input of the volume control. Follow this lead back toward the detector. If it goes directly to the bottom of the diode i-f winding, or to an r-f filter at the bottom of the winding, break the connection and make the bottom of the i-f winding (or r-f filter) your point *A*.

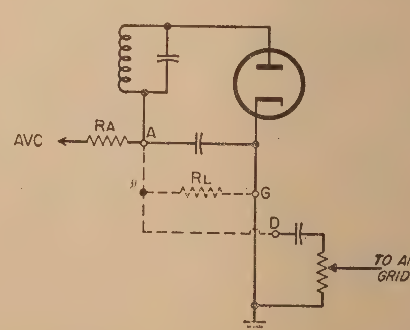


Figure 22.

Next check the other end of the volume control. If it is connected directly to ground this then becomes your point *G*. If this side of the volume control is connected to the diode cathode, it will probably be above ground through a self-bias resistor. The "hot" ground point, *G*, of the TNS is then connected directly to the diode cathode terminal—not to chassis ground.

Sometimes there will be two resistors in the diode cathode leg to ground. One end of the volume control will be connected to their junction. In this particular case, the TNS point, *G*, is attached to the same junction.

If there is a coupling capacitor connected between the input of the volume control and the bottom of the i-f winding, or r-f filter, then we will find some other resistor connected between one of the latter points and ground, or the diode cathode. (*see Fig. 22*) This will be the diode load resistor to be eliminated, as described earlier. Another way to check this is to start at the bottom of the i-f winding, or the r-f filter, and follow the path which provides the lowest resistance *d.c.* return path back to the diode cathode. This will indicate the diode load resistor.

Getting Around The Tone Control

Some of the most confusing circuits in the present day auto radios revolve around the weird combination of tone control arrangements. The manufacturers seem to delight in making a maze of various resistors and capacitors. They can be broken down and analyzed if we keep in mind that they are usually tied across the volume control input and at the same time are tapped into the control itself.

To install a TNS, leave these networks connected (even if only for the sake of the XYL). The output of the TNS, point *D*, should go to the volume control input and hence will react to the tone control variations in the usual manner. *Figure 27* is a fair example of a circuit of this type with *Ct* and *Rt* forming the tone control network.

Occasionally it will become impossible to obtain the optimum in silencing and squelch

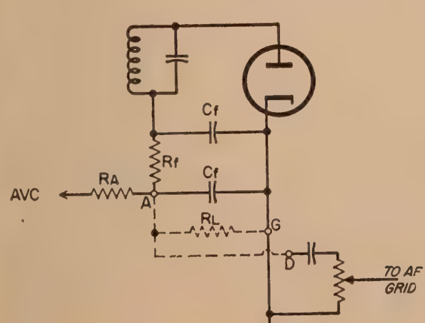


Figure 23.

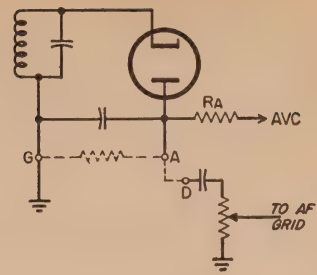


Figure 24.

operation with the TNS due to audio "leakage." This results from the use of a duo-diode triode in the car radio as a detector and audio amplifier. There is bound to be a certain amount of coupling through the common cathode of the diode and triode tube sections.

Checking for "Leakage"

To check your TNS installation for *leakage* turn the squelch control (*R7*) towards its maximum "no squelch" position and tune in a standard broadcast station. Remove the tubes from the TNS and turn up the volume control. If any audio from the broadcast station is heard there is *leakage* and steps should be taken to remove it. This involves separation of the detector and audio amplifier tube functions.

A similar check should be made using the high-frequency converter connected to the broadcast receiver. This check should be made at a location where the external ignition is heavy. Remove the tubes from the TNS and note whether or not the ignition pulses are leaking through. Ignition pulses from the car in which the equipment is installed may also be used, although complete *leakage* suppression may not be experienced in all cases, since heavy ignition pulses originating in your own car will often leak through in other portions of the a-f circuits.

With some type of noise limiters, *leakage* of this sort would not be noticeable. Usually it is light enough to be covered by other background noises coming through directly, under normal operating conditions. When a squelching TNS

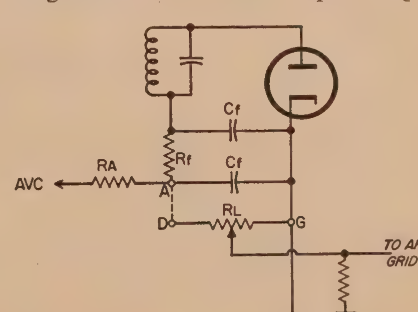


Figure 25.

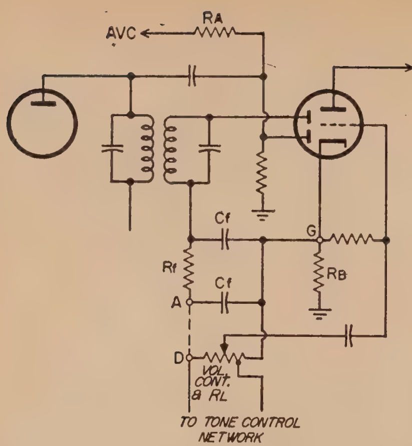


Fig. 26. Use of TNS in conjunction with tone control network.

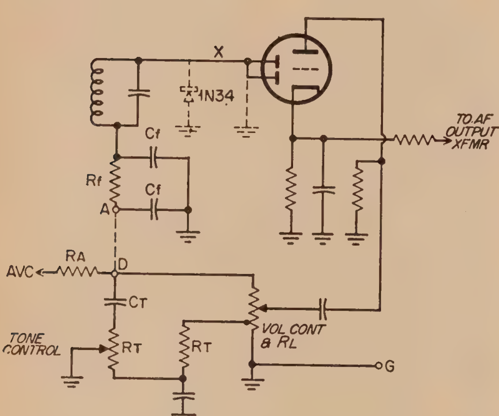


Fig. 27. Typical auto radio tone control circuit.

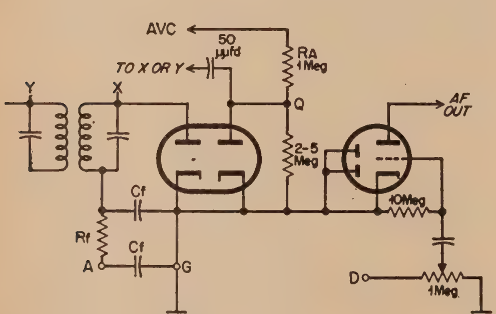


Fig. 28. A 6ALS may be added as a separate detector stage.

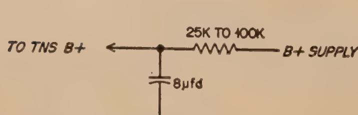


Fig. 29. Decoupling filter for TNS.

arrangement is used the directly received background is quieted and any leakage naturally will be noticed.

When the *leakage* is severe there is no alternative but to separate the detector and a.v.c. functions from the audio amplifier. *Figure 28* shows such an arrangement with a 6AL5 added to the circuit. The dashed lines of *Fig. 27* show suggested changes to incorporate a 1N34 as the detector element. Point "X" must be broken. This arrangement will save considerable space over the use of the 6AL5.

The general procedure if this changeover is necessary is to disconnect the diode plates of the duo-diode triode tube from the rest of the circuit. Then ground these diode plates. The *new* diode plates should be connected to the leads removed from the *old* diode plates. The cathodes of the *new* diodes should be grounded.

Motorboating in the TNS

A common trouble with the TNS is its tendency toward motorboating when the squelch or volume controls are advanced. In some cases it will be inaudible and only evidenced through distortion.* In practically all cases the motorboating is due to feedback through the B-plus circuits. A simple de-coupling filter will solve this problem (see *Fig. 29*).

Another source of motorboating is the audio feedback circuit between the a-f output stage and the cathode of the duo-diode triode. This is encountered in many auto radios, particularly those found in *Fords*. In these cases the feedback line is connected from either the primary or the secondary of the a-f output transformer to the diode cathode, which in turn is above ground through a resistor of from 68 to 2700 ohms (see *Fig. 27*). To get around this situation, the feedback line must either be disconnected and grounded, or the diode cathode must be grounded. Since this may eliminate the advantages gained in over-all audio quality, a better solution is to use a separate diode detector, as described above, leaving the feedback circuit alone. In *Fig. 27* this is shown as a crystal diode in dotted lines. The circuit is opened at point *X*.

In a few auto radios the motorboating may be due to the circuit shown in *Fig. 30*. Note that a tap has been made at the junction of the two resistors in the audio output stage to provide some biasing. Here again, the easiest and certainly the most effective solution is to replace the diodes in the duo-diode triode with 1N34's or a separate 6AL5. A very simple expedient might be to ground the diode cathode at a sacrifice in bias of this tube.

Where the TNS has been installed in a communications receiver, or one having high i-f gain, audio distortion and blocking often occurs with the reception of strong signals. If the

* The TNS should introduce no distortion and need not be switched out of the circuit for regular broadcast reception.

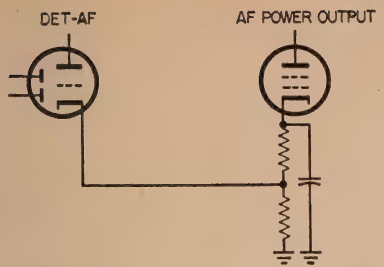


Fig. 30. Audio bias circuit found in some automobile receivers.

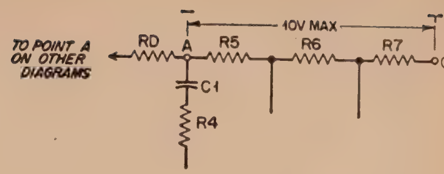


Fig. 31. TNS circuit is limited to a 10 volt input signal for minimum distortion.

potential of a received signal developed across the TNS load resistors *R5, R6* and *R7* is greater than 10 volts, severe a-f distortion will result. This potential should be measured, and, if found to exceed the 10-volt limit, should be reduced by inserting a dropping resistor, *Rd,* as shown at *Fig. 31.* The value of *Rd* will usually run around 150,000 to 220,000 ohms. Some loss in a-f level will result, but it should not be excessive.

Loss of Audio with the TNS

Some Hams, upon installing the TNS, become victims of a high loss in audio output from the auto radio. Obviously almost any type of limiting or silencing device will somewhat reduce the audio, but the loss should be within reason. In the TNS the resistors, *R5, R6* and *R7* represent a lower series value than the common load resistance they replace. This, together, in some circuits, with a volume control higher than 500,000 ohms, will often drop the audio level to a half or a quarter of that of the unmodified receiver. A method to improve this situation is to increase the respective values of *R5, R6* and *R7* simultaneously by a factor of from 5 to 10 times.

In some receivers a resistor of approximately 220,000 ohms will be found connected between the volume control and the bottom of the i-f winding; or the r-f filter. This resistor should be shorted out when the TNS is installed. By the way, don't make the mistake of trying to tap the B-plus from the plate terminal of the first audio tube (it has been done!) B voltage should come right from the supply. The TNS will operate within the range of 75 to 250 volts.

Proper Operation and Adjustment

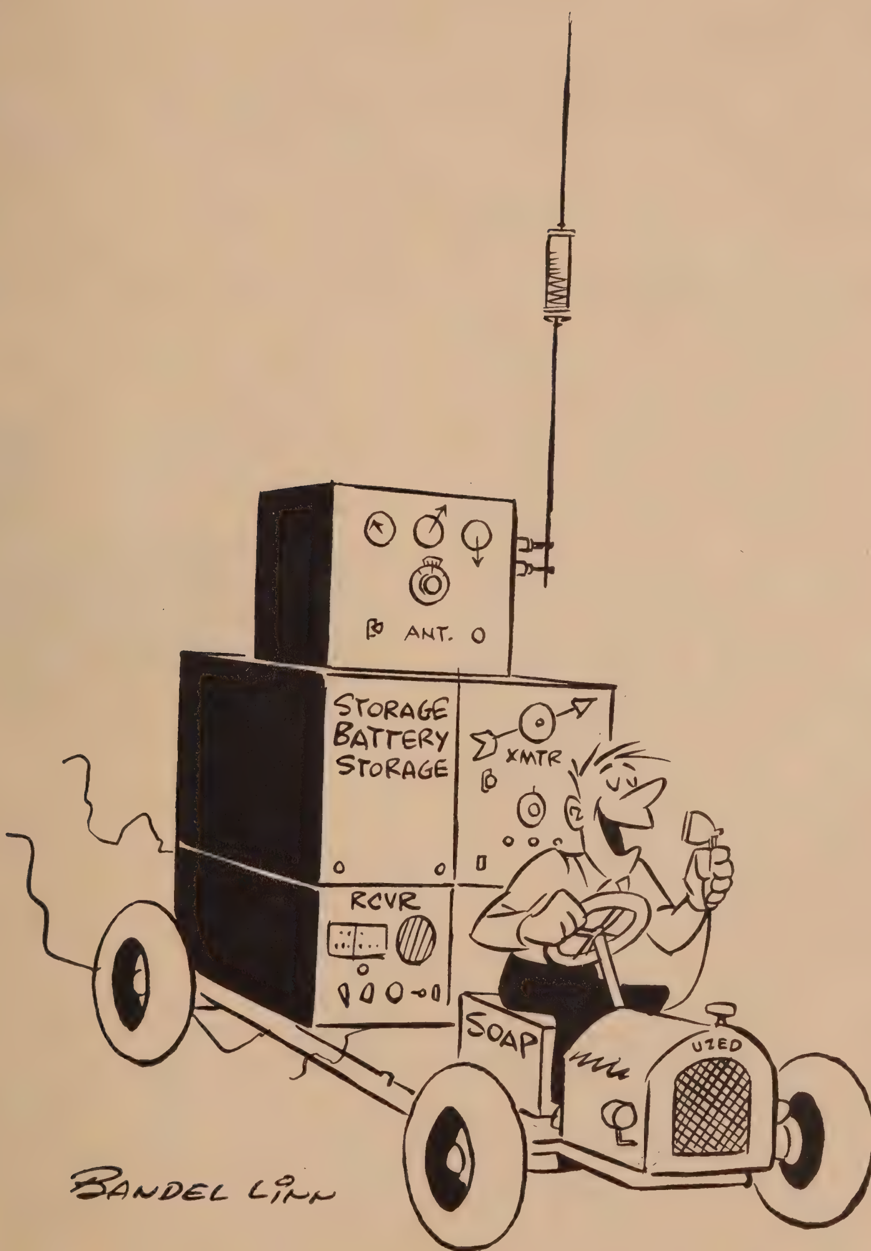
There appears to be some misunderstanding as to the correct method of operating the TNS. A few operators have complained about distortion which was later discovered to be due to an improper squelch control (*R7*) setting.

Turn on the converter and auto receiver and permit them to warm up thoroughly. Tune to a spot where there is no audible signal on the converter dial—just the background noise. Now adjust the squelch control to the point where the background level is just starting to drop out. Find the point where the background is causing the TNS to "chatter." This is because the TNS cannot make up its mind whether to squelch or let the background pour through. This is the critical threshold point where the weakest signal can be heard. If this chattering is annoying while on the road, turn the squelch on just a little bit more. If you turn the squelch control too far, the sensitivity will drop and the strong signals will become bady distorted. The stronger the signal the more the control can be advanced before distortion sets in.

On some potentiometers, the taper of the winding may crowd the threshold point until it becomes too sharp to set comfortably. This may be smoothed out by using a lower value at *R7* and placing it in series with a fixed resistor to make up the difference.

Chapter Five

Mobile Transmitters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Basic Requirements and General Design

The mobile transmitter has several distinct properties that tend to set it apart from fixed station equipment:

1. Size is an important factor.
2. The transmitter is usually remotely controlled.
3. The transmitter must be so built as to be shock resistant.
4. The control circuits are operated from 6- or 12-volts d.c.
5. The filaments *may* be of the direct heated type.
6. The transmitter is usually designed around the power supply unit.

Points one and two are self-evident and require no comment. Point three is exceedingly important. With the shocks and accelerations usually encountered in an automobile it has been found that the use of shock mounts on the mobile equipment is unnecessary and even undesirable. The equipment should, however, be firmly fastened down to the car frame so that it cannot shift position. Lock washers should be used under all machine bolts, and wiring should be laced. If much rough driving is contemplated, tube clamps should be used. They are not necessary for ordinary city driving. Clean, neat, and mechanically sound assembly, with a goodly amount of common sense built into it is all that is needed for successful construction of mobile equipment.

Points 4, 5 and 6 are directly related to the available primary power source. In some cases, where a large percentage of operation is planned when the automobile engine is not running it may be wise to use instant heating filament tubes in the transmitter. These may be turned completely off during periods of reception to conserve battery drain. These tubes are more expensive, more microphonic and more fragile than the indirect heater type which are to be preferred in most cases.

For those cars with 12 volt ignition systems there is a complete series of 12 volt heater tubes, both receiving and transmitting types. The 12 volt 807 pentode, the 1625, is highly recommended for mobile use. It is readily available on the surplus market at a very low price.

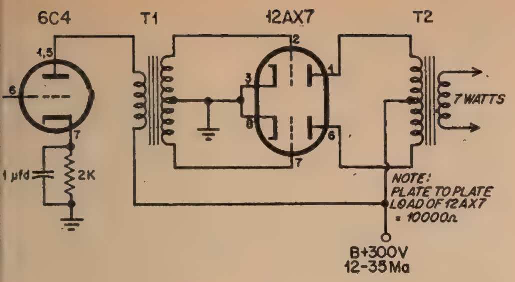
The control circuits may be operated directly from the d.c. primary circuit of the car. Operation of these circuits is discussed in Chapter 2.

Point 6 is extremely important and is often ignored by designers of mobile equipment. The power capabilities of most mobile supplies is strictly limited, and great care must be taken to insure that the transmitter design will work efficiently with the available power supply. For example, let us assume we have a 300 volt, 100 milliampere vibrator-type power supply and we wish to design a transmitter to work in conjunction with this supply, operating efficiently and not exceeding the rating of the vibrator unit. We may allocate the 100 milliamperes as follows: Oscillator-20 ma. Amplifier-45 ma. Speech amplifier-3 ma. Modulator resting current-20 ma. This gives a total power drain without modulation of 88 milliamperes. Under 100% voice modulation, the modulator plate current would rise to about 45 milliamperes, making the total current drain from the vibrator supply about 113 milliamperes. This is an intermittent drain, the average current being about 100 milliamperes or less with voice modulation. If a large value of output capacity is used in the filter system (10 μfd.) of the vibrator supply the voltage regulation will be very satisfactory, as the condenser will absorb the impact of the peaks of current caused by modulation. The power in-

W9HRM, the mobile station of the Milwaukee Radio Club.

put to such a transmitter would be about 13½ watts. With an amplifier efficiency of 70%, a 100% modulated carrier of 9½ watts would be radiated.

The next step upwards in power would be the use of a dual vibrator supply or dynamotor to supply 300 volts at 200 milliamperes. This power could be apportioned in this manner: Oscillator (and buffer, if one is used)—30 ma. Final amplifier—90 ma. Speech amplifier and driver—20 ma. Modulator resting current—20 ma. This gives us a total current drain without modulation of 160 milliamperes. Under 100% modulation, the modulator plate current would rise from 20 milliamperes to about 65 milliamperes on peaks. The total current drain, then, is 205 milliamperes. Again, a large capacity output filter condenser should be used in the output of the power supply. The power input to this transmitter is 27 watts, and the carrier power, assuming the same figure of 70% efficiency is 19 watts. The total primary drain in the first case was



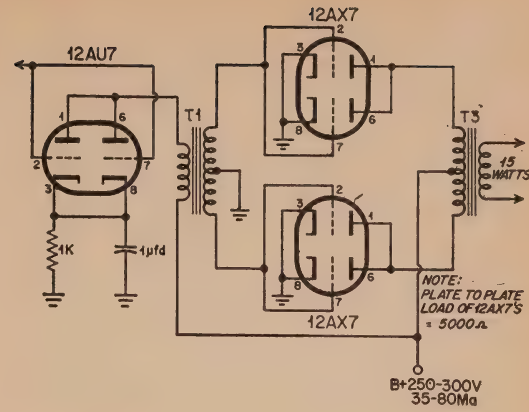


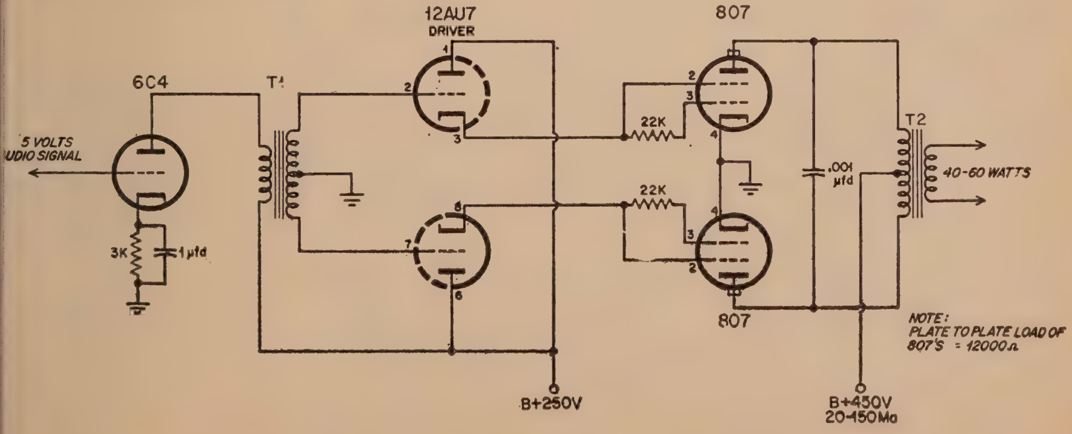
Fig. 1. The use of either of these two low-powered modulators is to be highly recommended. Transformer T1 may be a UTC S-8. Transformer T2 may be a UTC S-18, and transformer T3 may be a UTC S-19.

bout 50 watts of power. In the second case is about 100 watts. The signal is now 3.0 louder, or about ½ S-unit. This is just bout the minimum signal change that can be oted on a receiver signal. To gain another 3.0 b, it is necessary to increase the input to the ower amplifier to 55 watts. Let us see what is would entail.

It would be necessary to increase the plate oltage from 300 volts to the region of 400 500 volts. This takes us out of the power vel of the vibrator supply and puts us into e dynamotor bracket. At this jump we lose pproximately 10% power in conversion efciency, since the dynamotor consumes a fair mount of power just in the mere act of rotatg its armature. The popular PE-103A ynamotor will be used for this example. We ill draw 250 milliamperes at 450 volts from : Exciter stages—30 ma. Final amplifier—20 ma. Speech amplifier and driver—20 ma. Iodulator resting current—20 ma. This is a tal current drain of 190 ma. Under modulaon, the modulator plate current will rise to 00 ma. This is a total drain of 270 mills, well within the conservative rating of the PE-103A. The input to the power amplifier is now 54 watts, and assuming the usual 70% efficiency, a carrier of 38 watts is generated. This is exactly 3.0 db. louder than the transmitter using the two vibrator supplies, and 6.0 db. louder than the transmitter with the single vibrator supply. Our primary drain from the primary system of the car has increased to 200 watts. It can be seen from these examples that a 3.0 db. signal increase is bought dearly, costing an additional 100 watts of primary power for each 3.0 db. above the original 9½ watt carrier.

How much power to run? This is a personal problem, not a technical one. Most amateurs settle for a dual-vibrator supply or a 400-volt dynamotor as the middle course. A single vibrator supply transmitter does not leave the operator much of a margin for error when the carrier is less than 10 watts. Any slight inefficiency in the system will reduce the carrier to a minute value. A carrier of 15 to 25 watts starts to assume respectable proportions and is probably the best compromise be-

Fig. 2. This circuit provides more audio at a reasonable value of resting plate current. The 807's are operated as class B triodes. Transformer T1 may be a UTC S-2, while a UTC S-20 will serve as a modulation output transformer.



tween battery drain and transmitter output.

Choice of Tubes

A mobile transmitter is essentially a low voltage, high current device, and proper tubes must be used to meet this limitation, or it will be difficult to load the power amplifier to full input. For inputs under 15 watts the 6AQ5, 5763, 6V6, 6L6 or 2E26 will work well. These tubes can be loaded to a plate current of 40 to 45 milliamperes easily and without harm. For higher plate currents, at the 300-volt level, it is necessary to parallel two of these tubes, or to use tubes with more filament emission and higher perveance that will permit the use of higher plate current. The 6AV5GT and 6BQ6GT are recommended for this use. For 350 to 450 volt operation the 2E26, 807 and 6146 tubes are recommended. The 832 and 829 tubes are excellent, but they are usually too high priced for the average ham. In their place, the twin-pentode 815 will perform in a very satisfactory manner.

Several practical circuits may be used for modulators to improve the overall power efficiency level. For audio powers of 5-7 watts, a single class B 12AX7 tube works well. Two of these tubes in push-pull parallel connection will generate 15 watts of voice audio at 250 volts (*Figure 1*). For 300 volt operation the type 1635 tube is recommended. The 1635 is a special purpose 6N7 double triode that operates with a resting plate current of only 7 ma., compared with a resting plate current of 35 ma. for the 6N7. The socket connections and operating parameters of the 1635 are the same as those of the 6N7. The 1635 may be obtained on the surplus market or on special order through any wholesale dealer.

For operation in the region of 400-600 volts, two 807 tubes class B connected are recommended. The tubes are connected as class B triodes (*Figure 2*). The resting plate current drops from the usual value of 70 ma. to only 20 ma. when the tubes are so connected.

Modulation Considerations

Because of the relatively lower power inputs used with mobile transmitters and the lower efficiency of the antennas compared with fixed stations, the effectiveness of the modulation of a mobile transmitter takes on a high order of importance. (Effective modulation here means *enough* of the right kind of modulation.) For example, one may modulate 100% but have a bassy sounding audio such that 100% modulation occurs at 300 cycles and never at 1000 cycles.

The frequency spectrum of the human voice may be roughly divided into two regions: The first region contains all frequencies lower than 500 cycles. These frequencies contribute identification to the speaker. They tell whether the speaker is male or female and enable one to identify one male voice (or female) voice from another. The second region contains all frequencies above 500 cycles. These frequencies carry the message that is being spoken. A good example of these frequencies is a whisper. Everyone, man or woman, whispers alike. A blindfolded listener finds it almost impossible to distinguish one person's whisper from that of another. When one speaks normally, he is actu-

C1—0.005 μfd., ceramicon
C2—100 μμfd. mica
C3, C5—1.0 μfd., 200v.
C4—560 μμfd., mica
C6, C8, C9—0.001 μfd., ceramicon
C7—8 μfd., 450v.
R1—1000 ohms, ½w.
R2, R6—47,000 ohms, ½w.
R3—100,000 ohms, ½w.
R4—220,000 ohms, ½w.
R5—1500 ohms, ½w.
R7—100,000-ohm potentiometer
R8—750 ohms, ½w.
R9—500 ohms, 1w.
T1—UTC #S-8, class B driver
T2—UTC #S-19, 30-watt modulation transformer

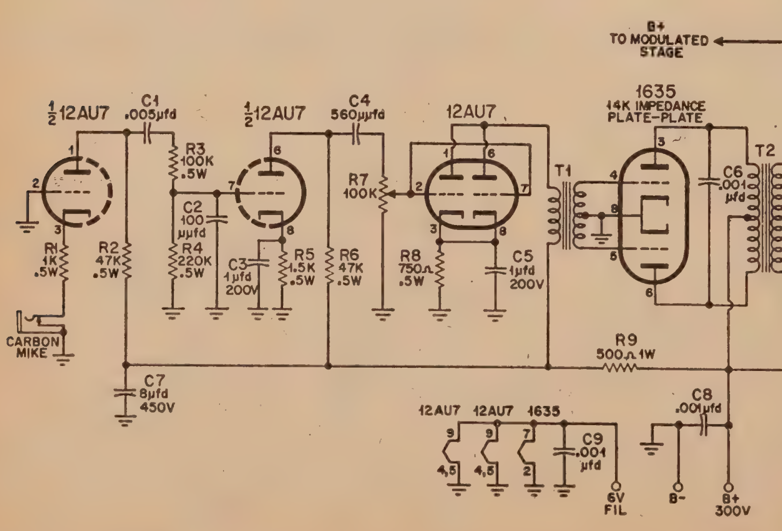
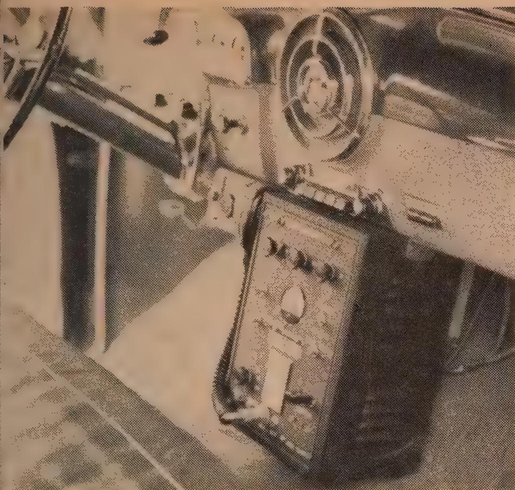


Fig. 3. This modulator is especially designed to incorporate speech waveforming (attenuation below 500 cycles and above 2500 cycles) with surprisingly low power drain.



W9CWB uses a TBS-50A as a mobile transmitter, mounted beneath the dash of his automobile.

ally still whispering, but he is also adding in lower frequencies which identify his voice. Some readers may recall having seen a demonstration of this by the Bell Telephone Laboratories' VODER, an electronic machine which created speech sounds, and actually could say words and sentences. The only sounds the VODER really made were a hiss, or whisper, and a low frequency buzz. These sounds could be put together by the operator of the machine into understandable speech.

Measurement taken on many male and female speakers show that the maximum energy in speech exists at about 500 cycles. The speech energy drops at a rate of approximately 6 db per octave above 500 cycles. It is this energy that carries voice intelligibility. Thus a modulation system with a flat audio frequency response may sound natural, but it certainly is not what is wanted for maximum intelligibility. Overmodulation will occur first somewhere around 500 cycles, leaving the intelligence carrying frequencies many decibels down from this value.

If all frequencies *below* 500 cycles are eliminated, no loss of intelligence occurs, and we will throw away about 65% of the total speech power, the function of this power being only to make the speaker sound natural. When we throw away this "make-natural" power by severely limiting the lower frequencies, we can modulate 4 db heavier on what frequencies remain—that part which gets the intelligence through! Of course in order to get this "free" 4 db we must have a modulation system capable of delivering it.

If, in the interests of signal bandwidth, we limit the high frequency response of the system to 2500 cycles, we will lose only about 18% of the syllables, and 3% of the words. Since more loss of words and syllables occurs because of QRM and fading than because of this restricted bandwidth, we may consider the cutting of high frequencies to be very desirable.

It was stated previously that the energy in the average voice drops about 6 db per octave above 500 cycles. If we employ a system that will boost frequencies 6 db per octave above 500 cycles, maximum modulation will occur at all audio frequencies simultaneously. The 2000 cycle frequencies will actually be 12 db higher in this system than the same frequencies in a "flat" system.

The last step is to employ speech compression. Peak amplitudes in speech are some 10 db greater than the average speech power, and since we have made all speech energies equal in our modulation system between 500 and 2500 cycles, compression of peaks will occur equally everywhere along the audio spectrum. We can now compress 6 db without harmful effects.

A complete modulation system, utilizing all these principles should have:

1. Complete attenuation below 500 cycles.
2. 6 db per octave boost from 500 cycles to 2500 cycles.
3. Attenuation of all frequencies above 2500 cycles.
4. About 6 db of speech compression.

This will provide maximum speech modulation effectivity in a mobile transmitter.

Low Drain Modulator

A circuit incorporating these first three features is shown in *Figure 3*. This modulator, using a 400 volt plate supply is capable of modulating 50 watts input to the final amplifier. With a 300 volt supply, it will fully modulate 25 watts input to the final stage. The total modulator plate current drain with no signal input is only 27 ma. This is less than drawn by a single 6N7 tube. For 300 volt operation, the total modulated plate current drain is just slightly over 50 ma. Assuming 50 ma. of current for the r-f section of the transmitter, this rating will allow the use of a single 300 volt, 100 milliampere vibrator supply for 300 volt operation. If a large output condenser is used on the vibrator supply, the slight voice peaks that produce a total plate current of slightly greater than 100 mills do not cause a sharp drop in plate voltage. At 400 volts the modulated plate current drain is 95 ma. at full output.

Referring to *Figure 3:* A dual 12AU7 tube is used as a grounded-grid cathode driven stage of speech amplification. The cathode current of the tube provides microphone current for the carbon microphone connected between the cathode bias resistor and ground. The R/C network between the plate circuit of this tube and the grid circuit of the second half of the 12AU7 provides some measure of response shaping.

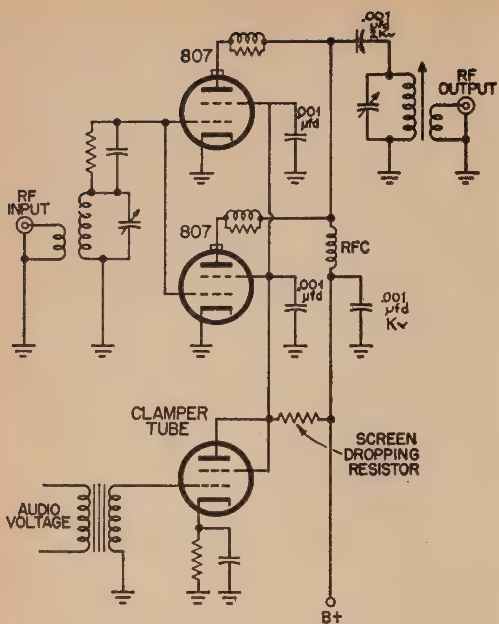


Fig. 4. This is the basic working schematic of the clamp tube modulating system. The audio wave varies the internal resistance of the clamp tube which in turn controls the screen grid voltage of the r-f stage..

C1/R3 provides a sloping response characteristic to attenuate the low frequencies, while *R4/C2* attenuates the high audio frequencies. Condenser *C3* in the cathode of the second section of the 12AU7 also offers some low frequency attenuation.

Network *C4/R7* provides a rising characteristic to the audio response between 500 and 5000 cycles. There is 6 db boost from 500 to 1000 cycles, 3-1/2 db boost between 1000 and 2000 cycles, and 1.8 db boost between 2000 and 5000 cycles. This response, combined with the shaping networks in the first 12AU7 stage provide a very satisfactory speech response. The audio is clear and crisp, and is very effective in cutting through heterodynes and other signals.

The second 12AU7 is connected in parallel to provide a source of power for driving the low impedance grids of the 1635 modulator. Transformer *T1* is a class B driver transformer, with a step-down ratio of 5:1. Condenser *C5* is chosen to attenuate the audio frequencies below 200 cycles.

The 1635 tube is an excellent low power modulator. It is a commercial version of the 6N7 tube, having higher voltage and dissipation ratings, and a substantially lower resting plate current with no audio excitation. With voice wave forms this tube will modulate 50 watts input to the final Class C amplifier stage.

Condenser *C6* is connected across the primary of the Class B output transformer. In conjunction with the leakage reactance of *T2* and the usual plate-to-ground bypass condenser in the final amplifier, this condenser forms a *pi-section* low pass audio filter, cutting off sharply at about 4000 cycles.

This modulator will work well with various r.f. tubes, such as the 2E26, 807, 6146 and 6AV5.

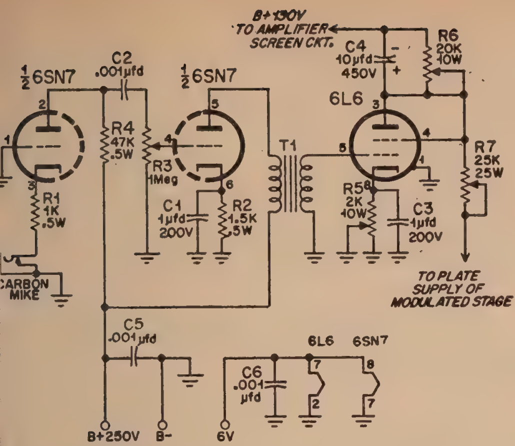
Screen Modulation

Since pentode tubes are in almost universal use in the modulated stages of mobile transmitters, it is natural to think of some form of screen modulation as an economical means of obtaining the maximum carrier power from the available primary power source in the car. Since screen modulation does away with the heavy current drain needed by a Class B modulator, it is an important type of modulation to be considered when designing mobile transmitting equipment.

Among the low power tubes, the 807 is one that is well suited for screen modulation. It can be modulated close to 100% with a suitable screen modulation system. It has a rather high impedance (high voltage, low current) screen circuit and requires but little audio for modulation. Other tubes with low impedance screen circuits (such as the 6146) are not as well adapted to screen modulation.

The most widely used system of screen modulation is the so-called "Clamp-Tube" system. It derives its name from the use of a screen clamper tube as a Heising modulator for the screen circuit of the r-f stage (*Figure 4*). Audio voltage is supplied to the grid of the clamp tube, and the internal resistance of the clamp tube varies at the audio rate. This varying resistance is placed in parallel with the resistance to ground formed by the screen grid circuit of the modulated stage. With a tube of high screen resistance and a large value of series dropping resistance, the varying resistance of the clamp tube has a very decided control on the voltage drop across the series resistance, and consequently the voltage applied to the screen of the r-f amplifier tube. But with the tubes of low internal screen resistance, the current is higher and the value of the series dropping resistor is lower and the control of voltage by the clamp tube is less effective.

A suitable circuit for modulating one or two 807 tubes is shown in *Figure 5*. The 6SN7 acts as a matching tube for a carbon microphone, and a single stage of transformer coupled speech amplification. The 6L6 tube acts as the "clamper-tube" modulator. In order to obtain a high percentage of modulation it is necessary for the 6L6 to swing the screens of the 807 tubes to zero voltage. Since the instantaneous plate voltage of the 6L6 never swings as low as zero volts, it is necessary to add the *R6/C4* circuit between the 6L6 and the 807 screens.



C1, C3—1.0 µfd., 200v.
C2, C5, C6—0.001 µfd., ceramicon
C4—10.0 µfd., 450v.
R1—1000 ohms, ½w.
R2—1500 ohms, ½w.
R3—1.0 megohm potentiometer
R4—47,000 ohms, ½w.
R5—2000 ohms, 10 watts, adjustable
R6—20,000 ohms, 10 watts, adjustable
R7—25,000 ohms, 25 watts, adjustable
T1—3:1 interstage

Fig. 5. A clamp tube modulator capable of controlling the screen voltage of one or two 807 tubes.

'4 will hold the d-c voltage constant under ıodulation, while *R6* allows the instantaneous :reen voltage of the 807 tubes to drop to zero nder modulation peaks, when the 6L6 plate oltage is at its lowest point.

Screen modulation is essentially a high voltge, low current system, and this system works est when 700 to 1000 volts are applied to the lates of the 807's. The minimum plate voltage or efficient clamp tube modulation of 807 ıbes is about 450 volts. This is the usual plate oltage obtainable in mobile work, and this ystem will work in a satisfactory manner with ıat voltage, but not with any lower voltage.

For best modulation, the coupling to the antenna system should be very tight, and less grid drive is desirable than with plate modulation. With the usual amount of antenna coupling, downward modulation will be noticed on an antenna ammeter.

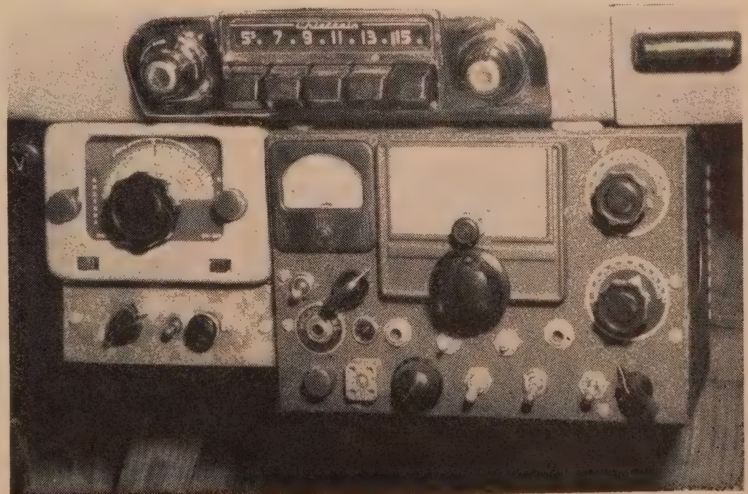
To adjust this system, *R7* should be set so that the plate voltage on the 6L6 is about 250 volts. *R6* should then be set so that the 807 screen voltage is about 130 volts. The higher the plate voltage, the greater can be the value of *R7* and the more effective is the modulation system. *R5* is adjusted for 20 volts bias on the 6L6 clamper tube.

After these adjustments have been made, the coupling between the modulated stage and the antenna should be increased until the antenna current drops about 15% in value. After this is done, the antenna current will kick up in a lively fashion under modulation.

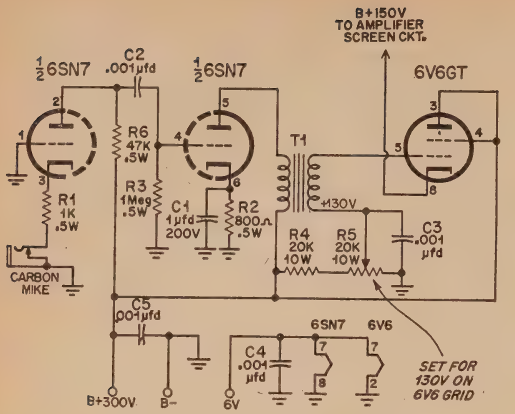
Gating Modulation

A superior type of "clamp-tube" modulation is the *Gating system*, wherein the clamp tube is a series connected element in the screen system, rather than a parallel connected element. The control tube now becomes a gate, or variable resistance having a very high internal resistance when no signal is applied to its grid, and becoming lower in value when a signal voltage is applied. A typical circuit is shown in *Figure 6*. The modulator load resistance is now in the cathode circuit of the control tube. Such a cathode follower requires a large amount of grid excitation voltage, and it is necessary to drive this stage with a transformer coupled voltage amplifier.

When the audio voltage is applied to the grid



The home-made VFO transmitter of W2RJL, along with a Gonset "Tri-band" converter forms a compact under-dash installation.



C1—1.0 μfd., 200v.	R4—20,000 ohms, 10 watts
C2, C3, C4, C5—0.001 μfd., ceramicon	R5—20,000 ohms, 10 watts, adjustable
R1—1000 ohms, ½w.	R6—47,000 ohms, ½w.
R2—800 ohms, ½w.	T1—UTC #S-2, 4:1 step-up
R3—1.0 megohm, ½w.	

Fig. 6. The "gating system" is a superior type of screen modulation. The control is effectively used as a gate or series element rather than a parallel variable resistance as shown in Fig. 4.

of this modulator, the positive peaks overcome some of the bias and the resistance of the tube is lowered and the screen voltage is raised. On negative peaks of audio the reverse takes place and the screen voltage becomes lower.

Since the full screen voltage of the r-f stage is applied to the cathode of the modulator, this circuit should not be used where the screen potential exceeds 300 volts or so. Fortunately, most screen grid tubes in mobile service take much less screen voltage than this for proper modulation.

Control *R5* sets the initial screen voltage on the modulated stage. If the d-c screen voltage is set low, a definite controlled carrier effect can be noticed. This is most pronounced when a high value of plate potential is applied to the screen grid stage.

The circuit shown in *Figure 6* will fully modulate a pair of 807 tubes with 450 to 1000 volts on the plates. The plate voltage on the 6V6 should be of the order of 300 volts. *R5* should be set for a cathode voltage of 150 volts from *pin 8* of the 6V6 to ground. If this voltage is set lower than this, the controlled carrier effect will be noticed, with both plate current and antenna current kicking up under modulation. With 150 volts on the screens of the 807 tubes, there is little if any controlled carrier effect.

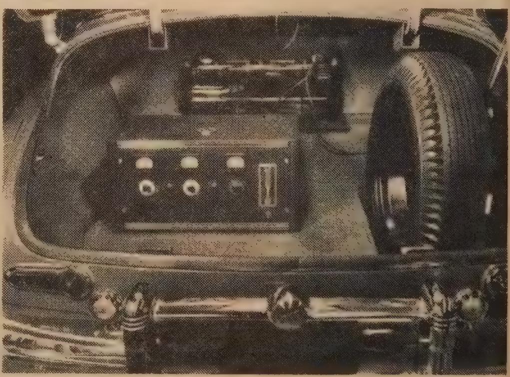
As with any type of grid modulation, the antenna should be tightly coupled to the modulator stage. Increase the antenna coupling and decrease the grid drive until the antenna current drops about 15% from maximum value. If this is not done, downward modulation will result and the modulation will sound "washed out".

With this, or any other type of grid or screen modulation, the efficiency of the modulated r-f stage will be of the order of 35-40%.

a Practical Screen Modulation Circuit

A simple series screen modulator designed to work with a single 807 or 6146 r-f amplifier is shown in *Figure 7*.

A dynamic or crystal mike drives V_1, a 12AX7, which is a cascaded amplifier with a gain of approximately 5000. The output of the second half of the 12AX7, approximately 150 volts peak to peak, is applied to both grids of V_2, a 12AU7. V_{2a} is used as an infinite impedance detector to provide a d-c voltage corresponding to the positive peaks of the audio signal. This d-c voltage on the cathode of V_{2a} is applied to the grid return of V_{2b}. V_{2b} is a cathode follower driving the screen of the 6146. The voltage at the grid of V_{2b} consists of the audio signal superimposed on a d-c voltage approximately equal to the positive peaks of the audio. Since the voltage at the cathode of V_{2b} very closely follows the voltage on its grid, this composite signal is applied to the screen of the 6146, resulting in controlled-carrier modulation. The low output impedance of the cathode follower results in an excellent modulation characteristic when driving the variable load represented by the screen of the r-f amplifier. It is true that 100% screen modulation cannot be achieved by driving the screen only to zero voltage with the audio signal, as is done in this modulator. (To completely screen modulate a tetrode, the screen must be driven slightly negative with respect to the cathode.) However, trapezoidal waveforms on a scope indicate that a satisfactorily high percentage of modulation is achieved, in the vicinity of 80%-90%.



The neat home-made mobile transmitter of W9QIO is mounted in the turtle-back, along with an auxiliary battery.

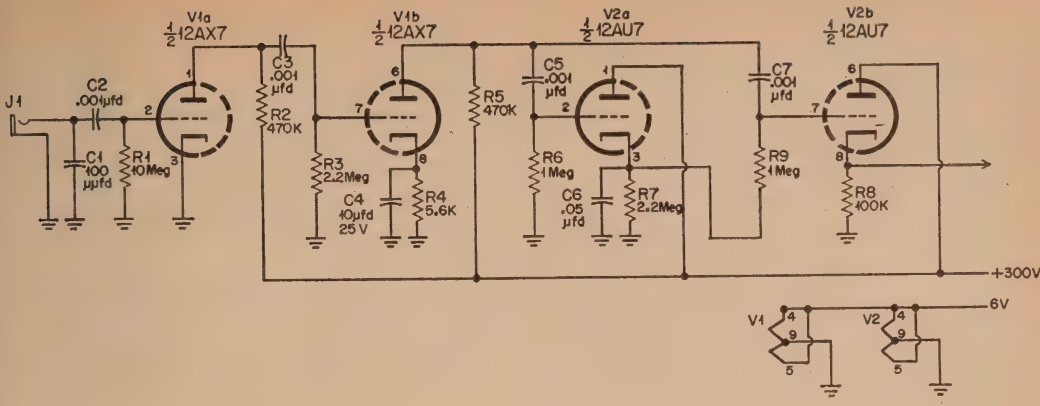


Fig. 7. Mobile screen modulator schematic. This circuit is for use with a ceramic-type crystal microphone.

The complete modulator may be built upon a 2"x4" chassis, or if used with a "Command" transmitter, may be built into the unused crystal socket and "magic eye" socket at the back of the set. If a carbon microphone is to be employed, the first section of the 12AX7 should be connected as a grounded grid stage, with the microphone inserted in the cathode circuit, as shown in *Figure 3*.

the W6MTY Screen-modulated Transmitter

Shown in *Figure 8* is the simple 75 meter phone transmitter used by W6MTY.

Since operation was desired only on 75- and 40-meter phone, the r-f section is conventional. The first half of the 6SN7 tube is used in a tuned-plate crystal-oscillator circuit. Plate voltage is lowered to a safe level by resistor, *R4*, and filtered of modulation products by the electrolytic capacitor, *C5*. For single-band operation, coil *L1* can be fixed. However, with the plate-tuning capacitor shown here, plug-in coils should be used for two-band coverage. Of course, a larger capacitor in the *C7* position would make one coil tune both bands, but this practice is likely to lead to harmonic and overdrive troubles, so it is not recommended.

The r-f amplified is capacitively coupled to the oscillator; and a split-stator capacitor with a plug-in balanced coil and center link is used in the plate circuit. The 6L6 tube requires neutralization, which is easily accomplished with this circuit.

A high gain microphone transformer *(T1)* and the second half of the 6SN7 tube comprise a simple speech amplifier stage.

To eliminate vibrator hash and car noises that have a habit of sneaking from the 6-volt system into a microphone circuit, a pair of 1½-volt cells in series are used to supply mike current.

Using the speech-amplifier tube and its load resistor as a voltage divider to supply the cathode-follower grid bias, eliminated another tube section. Thus, the modulator ends up as a simple voltage amplifier and cathode follower.

This method of biasing the cathode follower does not permit changing the operating point at will, but it is felt that the value of keeping things simple outweighs this disadvantage.

Construction and Operating Hints

The only rigid guide to be followed in the layout is: "Keep the leads short."

Terminals and jumpers are provided in amplifier-plate and grid circuits for metering, although the use of close-circuit jacks (insulating the plate one, of course) would facilitate the job. For checking currents, either a multimeter or separate 0-10 and 0-100 milliammeters can be used for grid and plate respectively.

To tune the transmitter, first connect the grid meter and remove the 6N7 modulator. Apply plate voltage and tune the oscillator-plate capacitor for not more than 2 ma. of 6L6 grid current. Then tune the 6L6 plate circuit to resonance, as will be indicated by a jump of the grid current. To neutralize the amplifier, adjust the control, *Cn*, for the least grid-current variation as the plate is tuned through resonance.

With the 6L6 tube installed, and its plate circuit adjusted to resonance, as shown by a dip in plate current, the screen voltage should be 150 volts, or one-half the supply voltage. If necessary, this voltage can be adjusted by changing the value of resistor, *R5* or *R6*. Bias voltage on the 6L6 grid should be set to 50 volts by adjustment of the oscillator-tuning control, as measured with a 20,000 ohms-per-volt meter through an r-f choke clipped onto the "hot" prod. When the oscillator is tuned "on the nose," the amplifier is overdriven, causing downward modulation. This should be checked after the antenna is coupled and the 6L6 tube is drawing its rated operating power.

The "Golden Gate" Circuit

A simple variation of the usual gating system has been employed by many amateurs in the San Francisco bay area with considerable success. Shown in *Figure 9*, this simple 75 meter phone transmitter employs but two tubes, a 6146 r-f amplifier, and a 12AT7 serving both as crystal oscillator and gating modulator.

The transmitter is tuned up in the normal manner, with *SW-1* placed in the "tune" position. The 6146 should be loaded heavily so the resonance plate current dip is almost eliminated. *SW-1* is then placed in the "operate" position and *R1* is adjusted for about 1/3 the antenna current obtained in the "tune" position. By making minor adjustments in the setting of *R1* and the antenna loading of the 6146 stage, excellent modulation may be obtained with this simple circuit. If desired, an 807 or 6BQ6-GT may be substituted for the 6146 tube when 300 volt operation is contemplated. In any case, the resistor in the oscillator circuit should be adjusted to provide 250 volts for correct oscillator operation.

This circuit may be modified as shown in *Figure 10* to modulate a "Command" transmitter. Both sections of the 12AT7 are placed in parallel and the screen bypass condenser of the transmitter is changed to 500 $\mu\mu$fd. to allow full modulation. To prevent frequency modulation, the oscillator of the "Command" set should be voltage regulated by a VR-150/30 in the plate supply circuit.

Speech Clipping for Mobile Transmitters

By employing speech clipping in mobile transmitting equipment a high percentage of modulation is possible without sideband splatter. This is of tremendous advantage in mobile work for the mobile transmitter is usually of low power, and the mobile signal is often much weaker than an equally powered signal from a fixed station. By limiting the frequency response of the modulator and keeping the average level of modulation as high as possible, the mobile station is able to hold its own among signals that are many times stronger.

With a complex waveform, such as that of the human voice, 100% modulation of the carrier is determined by the amplitude of the maximum peaks of the voice wave. These peaks occur at various intervals during speech and result in an *average* modulation level much less than 100%. The peaks are generally composed of vowels which contribute little to speech intelligibility, while the important consonants of less energy are down in the average level. The average modulation level is usually about 25-35%, depending upon the characteristics of the particular voice, the microphone, and the speech amplifier. This means that the averag power is far less than the "four times" carrie peak power attainable at 100% modulation. I the maximum peaks are suppressed or clipped the amplifier gain control may then be advance so that the average level containing the vita speech sounds will be increased without exceed ing 100% modulation, and the carrier will b more fully utilized. Thus a stronger audio signa of better intelligibility for cutting thru QRM will be realized.

Clipping creates a certain amount of distor tion dependent upon the degree of clipping. In practice, 10 db or so is a maximum usabl amount, as distortion becomes objectionabl above this value.

In order to prevent the high frequency har monics created by the clipping process fron modulating the carrier and causing sideban splatter, a low pass filter should be installe following the clipping stage. This filter shoul cut off at about 3500 cycles, permitting ampl high frequency response for voice transmissions yet limiting excessive high frequency response Speech clipping may be done in the low powe speech amplifier stages preceding the modulator or it may be done after the modulator and be fore the modulated amplifier.

High Level Clipping

The circuit for a typical high level clippe suitable for mobile use is shown in *Figure 11* This type of clipper is fully automatic in oper ation, and will allow extended positive modula tion peaks while fully limiting the splatter causing negative modulation peaks. Condenser *C1*, *C2*, *C3*, and *C4* in conjunction with chok *L1* form a low pass filter, attenuating all fre quencies above about 3500 cycles. The induc tance of the modulation transformer secondar winding, plus *C4* and *C5* form an additiona *constant-K* section low pass filter, giving addi tional attenuation to the unwanted frequencies

The clipper tube is placed on the B-plus sid of the modulation transformer. As can be see from the circuit, there is a potential differenc of about 400 volts between the cathode of th clipper tube and its filament, one side of whic is at ground potential. The maximum operatin potential of the clipper tube, therefore, is th maximum cathode-heater potential at which th tube will operate safely. For the 6X5 tube, thi potential is 450 volts. If the clipper tube i placed between the modulation transformer an the modulated stage, the plate voltage of th transmitter would have to be dropped to 22 volts, since under 100% modulation the cath ode-heater potential would reach twice th operating plate voltage, or a value of 450 volts When the 6X5 is placed *before* the modulator its operation is identical with the above case *except* that the cathode-heater potential is equa to the operating plate voltage under 100% mod ulaion. Thus the plate voltage to the transmitte may safely be raised to 450 volts, the maximun cathode-heater voltage rating of the 6X5.

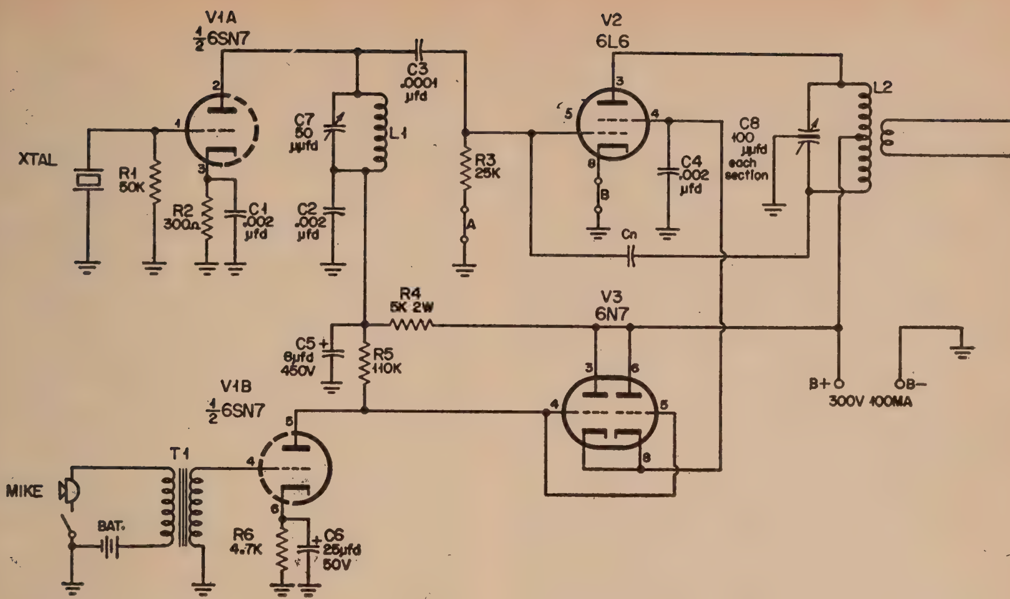


Fig. 8. Complete schematic for the W6MTY mobile transmitter. Cn is a 3 $\mu\mu$fd TV-type trimmer.

The 6X5 will safely pass a plate current of 70 ma. For currents up to 125 ma., a 6AX5 tube may be used. For greater plate currents, two tubes in parallel should be used.

For plate voltages above 350 volts, an OZ4 gas rectifier may be used. One of these tubes will safely pass 75 ma., and since it has an ionically heated cathode that operates "above ground" (*Figure 11*) there is no danger of internal breakdown within the tube. Two or more OZ4 tubes may be used in parallel for greater current capacity provided a 100 ohm 1 watt resistor is placed in series with the anode of each tube to equalize the current thru the tubes. The OZ4 tube cannot be used at operating potentials of less than 325 volts, since it takes this voltage to "fire" the tube and start it operating.

For plate voltages up to 1200 volts, it is possible to use selenium power rectifiers as high level clippers. The selenium rectifiers should be insulated from ground to prevent voltage breakdown. Suitable rectifiers are listed for various current ratings in *Figure 12*.

The usual high level filter is a *pi-section* filter composed of a choke of from 0.1 to 1.5 henries inductance and condensers of from .003 μfd. to .01 μfd. capacitance (*Figure 13*). It must be remembered that the plate bypass condenser of the modulated stage is in parallel with condenser *C2*. The plate bypass condenser may be made to act as *C2* by making it the correct value for the filter. Special "splatter chokes" are made by Chicago Transformer Co., Triad Transformer Co., Standard Transformer Corp., and others that have a tapped winding to cover the above inductance ranges. The condensers used in the filter should have a d.c. working voltage rating of three times the unmodulated plate voltage of the transmitter. The correct values of capacitance and inductance for the filter are shown in *Figure 13*.

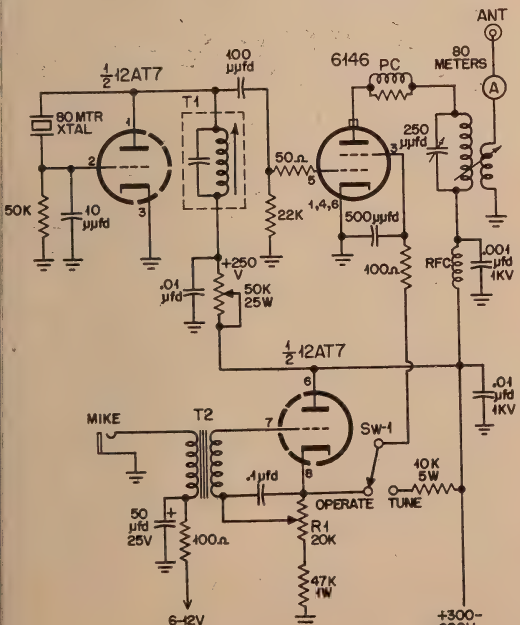


Fig. 9. The "Golden Gate" screen modulation circuit applied to a 6146 tube.

T1—J. W. Miller #1470 coil
T2—Mike transformer. Triad A-5X

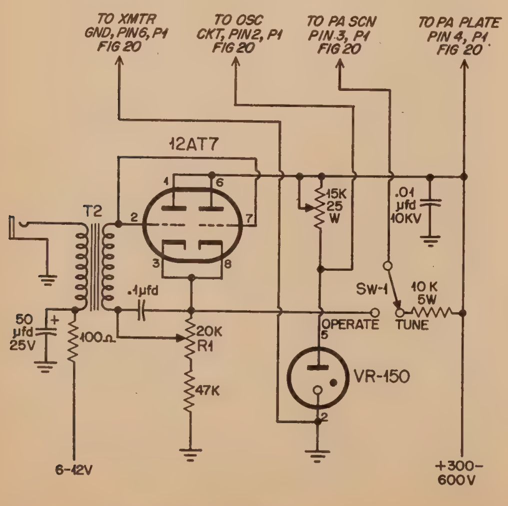
a Clipper-Modulator for the Mobile Transmitter

Shown in *Figure 14* is the schematic of a modulator unit capable of fully modulating a 50 watt mobile transmitter. Low level clipping and filtering combined with high level filtering allow a maximum of voice energy to be applied to the transmitter before the point of over-modulation is reached.

A 12AX7 is employed as a two stage speech amplifier. The first section of this tube is a grounded grid amplifier, to be used with high gain carbon microphones. The microphone is connected in the cathode circuit of the tube, the plate current of the tube furnishing exciting current to the microphone. If more gain is needed, the alternative input circuit may be substituted for the grounded grid stage. A microphone transformer provides a high voltage step-up ratio between the microphone and the grid of the 12AX7 input stage. Microphone voltage is obtained from the d.c. filament supply of the transmitter through a simple R-C filter network.

The coupling condenser between the two 12AX7 stages is chosen so as to limit the low frequency response of the amplifier. This results in a reduction of the "canting" of the clipped wave which occurs as a result of the phase shift through the succeeding stages. Approximately 25 volts (peak-to-peak) is delivered by the 12AX7 to the clipper stage under maximum gain conditions.

A series-clipper diode circuit employing a 6AL5 provides a clean, clipped wave. The clipping level is controlled by a potentiometer which varies the plate potential applied to the two series diodes. A clipped wave of about 5 volts peak level may be obtained from the clip-



per. To restrict the harmonics above 350(cycles that are generated by the clipping action a low pass filter follows the clipper. The outpu of the filter is applied to a 12AU7 double triod functioning as a "voltage-divider" type phas inverter. Sufficient voltage may be obtaine from this inverter to properly drive a pair o beam tetrodes to maximum output.

Either 6L6, 807 or 5881 tetrodes may be use in this circuit, depending upon the maximur plate supply voltage applied to the tubes. Th speech amplifier and the tetrode screens are fe from a 300 volt supply. The current drain o this circuit is about 15 to 20 ma. If 300 volts i applied to the plates of the 6L6 tubes, th cathode resistor should be dropped to 150 ohms About 20 watts of audio may be obtained, wit a plate current of about 125 ma. to the 6L6's If the plate voltage is increased to about 36 volts, the cathode resistor should be increase to 250 ohms, and approximately 25 watts o audio may be obtained.

If the cathode of the 6L6 tubes are grounde and a small 22½ volt battery connected in th grid circuit to bias the tubes, approximately 3 watts of audio may be obtained at a plate volt age of 360. Proportionately higher output ma be obtained at higher values of plate voltage Complete specifications for the operation o 6L6 tubes as audio modulators may be obtaine from the RCA tube manual RC-17.

To reduce the higher order harmonics ger erated in the 12AU7 and 6L6 stages, a low pas audio filter is connected between the modulate amplifier and the output of the modulator. Th use of this additional filter greatly reduces th sideband "splatter" so commonly associate with mobile transmitters.

The actual level of modulation is controlle by the clipping potentiometer in the 6AL stage. This limits the audio level to any pre determined value. This control is set so that n audio peaks pass over the value necessary fo 100% modulation. Once this level has bee established, the audio gain control is advance until just enough audio is applied to the clippe to permit 100% modulation. Any increase i audio beyond this point will actuate the clippe and will not be passed to the modulated stag With an adjustment of this type, the clipper ac as a modulation limiter, preventing overmodul tion of the transmitter.

If the plate voltage applied to the 6AL5 cli per is now further reduced by moving the ar of the clipping potentiometer closer to th ground end of the control, additional clippir will be brought into play. About 10 or 12 db o clipping may be added before the modulatic

Fig. 10. "Golden Gate" modulator for "Command" transmitter.

1—T2 same as in Fig. 9
2—Screen bypass condensers of f-a stage (C11, C12) reduced to 500 uufd each, Fig. 20

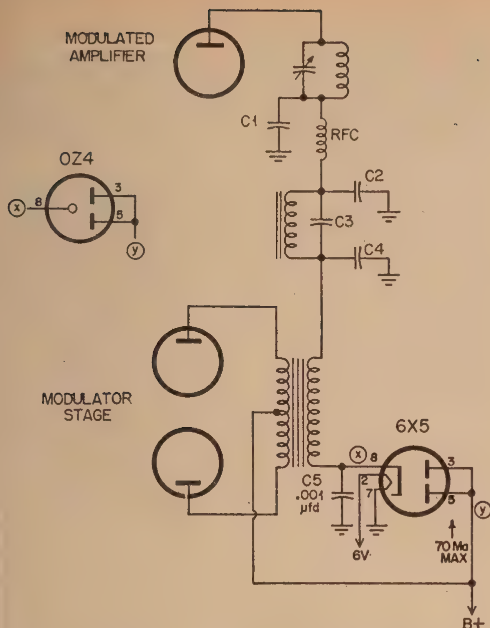


Fig. 11. High level speech clipper and filter suitable for mobile use. An OZ4 tube may be substituted for the 6X5 when the plate voltage and current are high.

tarts to sound "mushy". With the extra clipping, the modulation will take on a degree of heaviness and force that will make for easy copy under conditions of QRM. Too much clipping will make the voice sound "boomy" and difficult o read. The correct adjustment of the gain and clipping controls is not hard, and may be done n a moment with the aid of a nearby monitor. t is best to start with no clipping and add it gradually until the correct level is achieved.

12AX7 Modulator

The miniature 12AX7 tube makes an excelent Class B modulator for low powered mobile ransmitters. Operating with a plate potential of 300 volts, the 12AX7 requires no bias, having a resting plate current of only 10 ma. This is ower than any other tube capable of producing he same amount of audio power. The resting plate current of the 6N7 is 35 ma., and the esting plate current of the 1635 is 11 ma. The popular push-pull 6AQ5 modulator draws a ninimum plate current of 70 mils even when he stage is overbiased.

When mobile operation is contemplated using a single vibrator supply, it is of the utmost importance that unnecessary current drain be cut o an absolute minimum. The use of the 1635 or the 12AX7 as a modulator is almost mandatory.

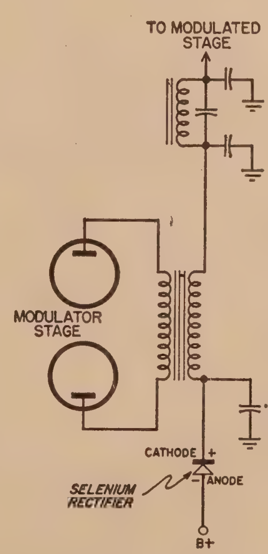
The 12AX7 will deliver 7 watts of voice audio with negligible distortion when operating at a plate potential of 300 volts. The resting plate current is 10 ma., kicking up to about 35 ma. under modulation peaks. The 12AX7 may be easily driven by a single 12AU7. The first half of the 12AU7 is connected as a voltage amplifier, with a *high gain* carbon microphone in the cathode lead. The second section of the 12AU7 is a transformer coupled driver for the 12AX7. The total plate current drain of the two tubes is 43 ma. when delivering 7 watts of audio (*Figure 15*).

Two 12AX7 tubes may be used in push-pull parallel to obtain 15 watts of audio power (*Figure 16*). More drive is needed for this circuit, so the 12AU7 driver tube is connected as two transformer coupled stages, the carbon microphone being connected in the cathode of the first section of the 12AU7.

The correct load impedance for a single 12AX7 is in the vicinity of 14,000 ohms. Two tubes connected in push-pull parallel require a load impedance of 7,000 ohms.

Because of the simplicity of these circuits, it is hard to do much forming of the voice response characteristics of the modulator. A drop in low frequency response can be made by reducing the value of the coupling condenser *C2* in *Figure 15* to .001 µfd. The high frequencies are cut sharply by *C3* acting in conjunction with the leakage reactance of *T2* and the plate bypass condenser of the modulated amplifier.

In *Figure 16* the low frequency response is controlled by *C1* and by the loss of low frequencies caused by the 12AU7 plate current



MAX. CLASS C PLATE CURRENT	MANUFACTURER
75	SELETRON 5M4 FEDERAL 1014A
150	SELETRON 6P2 FEDERAL 1029A
300	SELETRON 6QS2 FEDERAL 1022

Fig. 12. Selenium rectifiers may also be used as high level clippers. One rectifier may be used for plate voltage up to 400 volts. Two in series should be used for plate voltage from 400-800 volts.

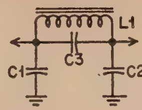


PLATE LOAD (OHMS)	C1,C2 (μfd)	L1 (HENRIES)	C3 (μfd)
2500	.015	0.18	.011
3000	.013	0.21	.01
3500	.011	0.25	.0085
4000	.009	0.27	.007
4500	.008	0.30	.0062
5000	.007	0.38	.0055
5500	.0066	0.42	.0052
6000	.0062	0.47	.0047
6500	.006	0.50	.0043
7000	.0055	0.54	.004
7500	.005	0.58	.0038

Figure 13. This table will enable a high level filter to be designed for 3000 cycle cutoff with various plate loads.

flowing through the primary winding of *T1*. High frequency response is controlled by *C2* connected across the primary winding of *T3*.

The octal based 6SN7 may be substituted for the 12AU7, and the 6SL7 may be substituted for the 12AX7.

Mobile Conversion of the "Command" Transmitters

The "Command" units (known variously as ATA, ARA, ARC-5 or SCR-274N equipment) make excellent mobile transmitters. They may be modified for mobile work with little effort, or the transmitter may have a major design overhaul, at the whim of the user. Various modifications of this popular equipment may be found on the mobile bands, from 160 meters to 6 meters. The following information is divided into two parts: (1) Conversion and modernization of the basic equipment for 80- and 40-meter operation, and (2) Conversion and modernization of the circuitry for 20, 15 and 10-meter operation.

Parts List

T1—UTC S20 modulation transformer
T2—Microphone Transformer. Triad A-5X
L1 — "Splatter" choke. Triad C-26X
C1, C2, C3—Determined by data furnished with L1, or from Figure 13
LPF2—"Splatter" filter. Chicago Transformer LPF-2

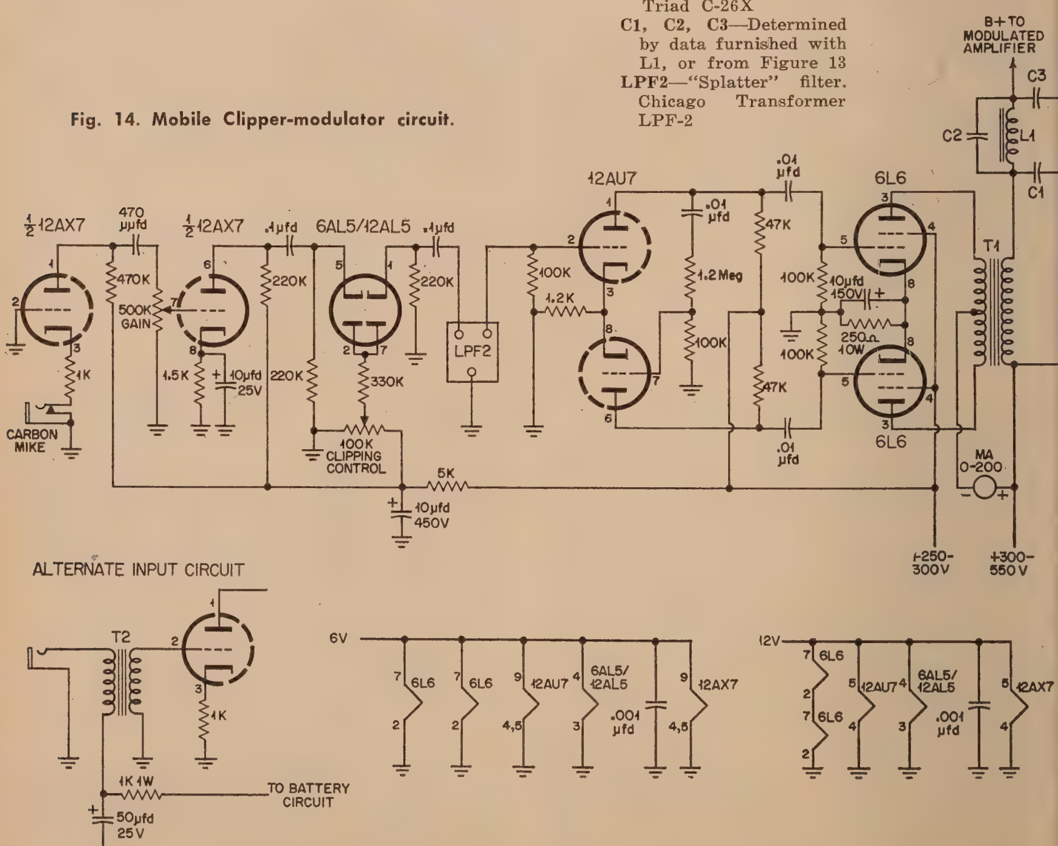


Fig. 14. Mobile Clipper-modulator circuit.

The Basic "Command" Transmitter

A type 1626 tube is used as a variable fre-uency oscillator, operating on the fundamental requency of the transmitter, exciting a pair of 625 tetrode amplifier tubes which are con-ıected in parallel. The variable oscillator and he power amplifier tuning are ganged for sim-ılification of controls. Continuously variable nductive coupling between the power amplifier ank circuit and the antenna circuit is controlled y the "Antenna Coupling" knob on the front anel. The antenna circuit is resonated by a ontinuously adjustable series inductor.

A quartz crystal resonator is incorporated n each transmitter for use with a 1629 "magic ye" tube to *check* the accuracy of transmitter alibration at one frequency—the crystal *does ıot* control the transmitter frequency.

The transmitters are designed to operate with single wire antenna having reactance limits of 0-$\mu\mu$fd. or 4.5 microhenries, and a resistance f not over 12 ohms. A basic functional dia-ram of the "Command" transmitters is given n *Figure 17*.

The Transmitters—

AN Number	*Navy Number*	*Army Number*	*Frequency Range*	*Xtal Check*
-18/ARC-5	52232	———	2.1-3.0 Mc.	2.5 Mc.
-19/ARC-5	52208	BC-696	3.0-4.0 Mc.	3.5 Mc.
-20/ARC-5	52209	BC-457	4.0-5.3 Mc.	4.6 Mc.
-21/ARC-5	52210	BC-458	5.3-7.0 Mc.	6.2 Mc.
-22/ARC-5	52211	BC-459	7.0-9.1 Mc.	8.0 Mc.

These v-f-o transmitters are all similar hysically, only the tuning inductances and rystals are changed for each band. The JAN eries transmitters differ slightly from the Army nd Navy versions in that they have shunt feed n the power amplifier stage and different power eceptacles that will not match the standard CR-274N racks. Because of the shunt fed cir-uit, the ARC-5 transmitters may be plate nodulated at a potential of 700 volts or so, with o danger of flashover. A typical transmitter ircuit applicable to all models is shown in *igure 18*. A bottom view of a command trans-nitter with standard Armed Services nomen-lature is shown in *Figure 19*.

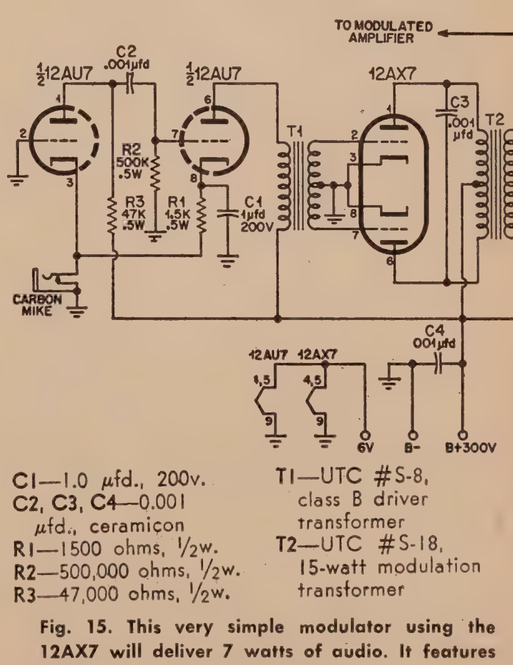
Modernization and Conversion of the Transmitters for 80 and 40 Meters

For six-volt operation, all transmitter tubes nust be changed, and relays *K-53* and *K-54* emoved. The filament circuits must be changed rom series connection to parallel connection. ince the electron eye indicator is rarely used n amateur operation, it may be removed com-letely along with the calibrating crystal, thus implifying the conversion. The complete con-ersion, including TVI measures, calls for re-lacement of all by-pass condensers, and the hortening of ground return leads. One of the asic faults with the original transmitters is he faulty grounding and bypassing caused by ong ground leads and inductive condensers. While the conversion to six volts is being done, it is very little additional work to modernize the circuits, and clean up the TVI and parasitic problems. The revised schematic, applying to units intended to work in the 80 and 40 meter bands, is shown in *Figure 20*. The conversion steps are:

1—Remove the 1629 electron eye socket and the resistors mounted on it. Remove re-sistor *R-71* mounted above the socket. Remove the crystal calibrator socket and its associated resistors. Take out *C-58* (see *Figure 19*) and all the small components beneath the chassis except the neutralizing condenser, *C-62*, and the *C-59/R-72* combination in the oscillator grid circuit. Remove *J-64*, the power plug on the rear of the chassis. (If the transmitter is going to be operated with a standard command rack this plug should be left on the chassis.) Remove all wiring below the chassis except the solid, tinned leads from the oscillator socket to the oscillator coil, *T-53*, the solid wires in the control grid leads of the p-a. stage, and the wire from *C-62* to *T-53*.

2—Above the chassis, remove *K-54* and its wiring. Remove the antenna terminal and replace it with a coaxial fitting. (*Amphenol 83-1R*.) Connect the loading coil arm to the center pin of the coaxial fitting.

3—A 6J5 tube can directly replace the 1626 oscillator, and 807 tubes can replace the 1625 tubes in the p-a stage. To do this, the sockets for the 1625 tubes must be modified from seven pin sockets to five pin sockets to fit the 807's. This may be done as shown in *Fig. 21, Pg. 113*. Holes 2, 4 and 6 should



C1—1.0 μfd., 200v.
C2, C3, C4—0.001 μfd., ceramicon
R1—1500 ohms, ½w.
R2—500,000 ohms, ½w.
R3—47,000 ohms, ½w.
T1—UTC #S-8, class B driver transformer
T2—UTC #S-18, 15-watt modulation transformer

Fig. 15. This very simple modulator using the 12AX7 will deliver 7 watts of audio. It features a resting plate current of only 10 ma.

filed out with a small "rat tail" file to accept the 807 base pins. Before any filing is done, the pin spring clips should be removed and the contacts spread apart to prevent damage to the clips during the filing operation. These clips should be replaced when the sockets have been modified.

4—Enlarge the rear power plug hole to 1¼″ diameter, and mount an *Amphenol 86-CP6* six prong male plug in this hole. Before the plug is mounted, short lengths of No. 16 tinned wire should be soldered in each pin, and condensers *C4, C5, C6, C7* and *C14* (see *Figure 20*) connected to these wires. The condensers (and *pin 6*) are grounded to the socket mounting bolts. These condensers prevent spurious radiation thru the power leads and greatly reduce TVI problems.

5—*C1* is mounted on the 6J5 socket between *pins 3* and *1*. *Pin 1* is grounded. *C2* is mounted on *pin 5* of *T-53,* counting from the rear pin towards the front of the transmitter. It is grounded to the soldering lug directly beside *pin 6*. *C8* is connected to *pin 4* of *T-53* and grounded by a lug placed under the adjacent chassis screw. *R2* and *R3* may be mounted by a small insulated terminal strip placed on the side wall of the chassis in the space formerly occupied by *C-64,* the old screen bypass condenser.

6—*C3, C9, C10, C11* and *C12* are connected directly to the pins of the 807 tube sockets. The ground leads of these condensers should be soldered to the frame of padding condenser *C-67* directly below the socket pins. It is very important that these condenser leads should be short.

7—*C13* and *RFC1* are mounted just below the insulated bushing thru which the B-plus lead from *T-54* passes. Note that both *C13* and *C7* are special high voltage *ceramicon* condensers. As a final step, a closed circuit jack, *J1* is mounted in the lower left corner of the front panel.

The rotatable loading coil, *L-52,* is left in th circuit to permit the use of the transmitter witl a wire antenna, but it should be set at zero fo operation of the transmitter into a coaxial line

If it is found impossible to load the trans mitter to as high a value of plate current a desired, the small rotating pickup coil, *T-54E* may be removed from the p-a tank assembl and rewound with more turns of wire. This wi allow greater coupling between the transmitte and the antenna.

Testing and Alignment

The transmitter wiring should be checkec Six volts should be applied to *pins 1* and *6* c *P1* and 200 volts d.c. to *pin 2*. The oscillatc should be checked on a nearby receiver an *C-60* reset, if necessary, for correct coverage c 80 or 40 meters. Plate and screen voltage should be applied to the 807 stage, and cor denser *C-67* in the p-a stage re-resonated an locked. This adjustment should be made in th middle of the amateur band. The slug of *T-5* may be adjusted if the two stages do not trac properly across the band. The transmitter ma now be connected to a suitable antenna an loaded up to an amplifier cathode current c 225 ma., as measured in *J1*. Screen voltag should be set at 250 volts.

As a final adjustment, a 0-50 ma. mete should be connected between *pins 5* and *6* c *P1* and the grid current of the 807 tubes mea ured. The plate voltage of the 6J5 oscillatc should then be adjusted until a grid current c 8 ma. flows under operating conditions. Tl plate voltage on the 6J5 will be about 180-22

C1—1.0 μfd., 200v.
C2, C3, C4—0.001 μfd., ceramicon
R1, R2—1000 ohms, ½w.
R3—500,000-ohm potentiometer
T1—Merit #A-2910 interstage transformer
T2—UTC #S-8, class B driver transformer
T3—UTC #S-18, 15-watt modulatio transformer

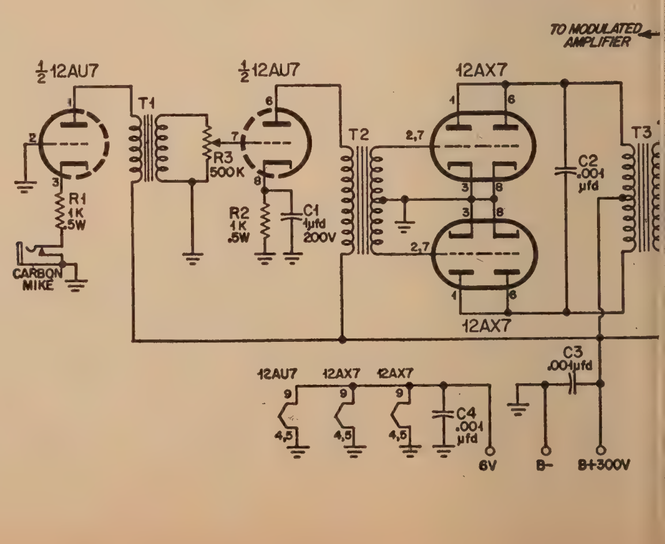


Fig. 16. For 15 watts of audio the circuit of Fig. 15 may be modified into a push-pull parallel amplifier.

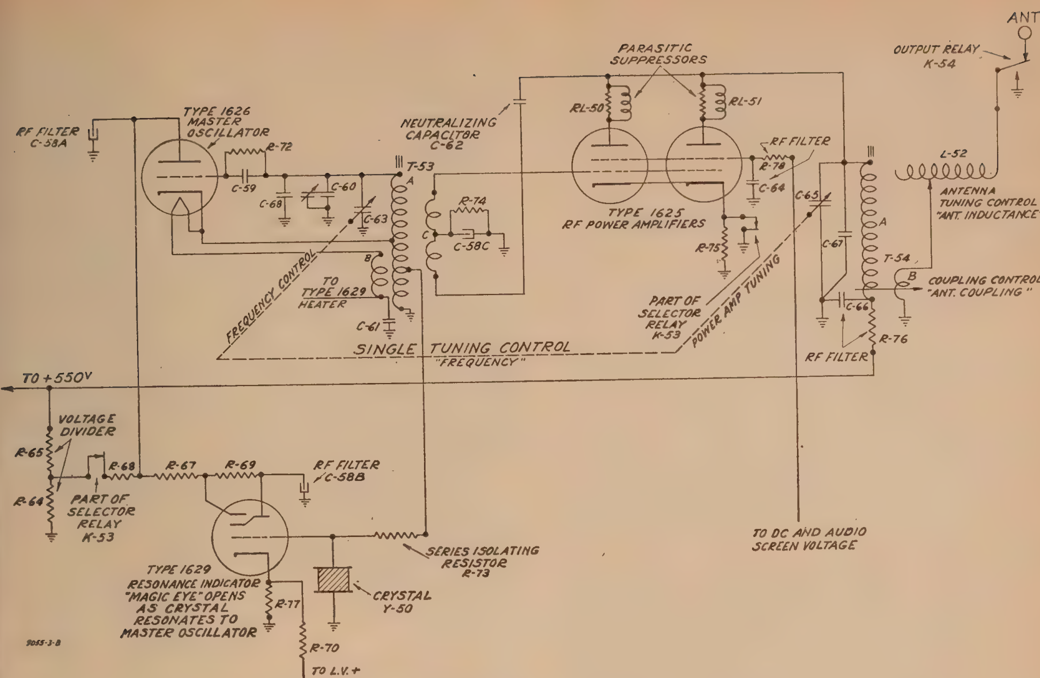


Fig. 17. Functional diagram of "Command" transmitter.

volts when this adjustment is completed. The transmitter is now ready for installation in the car.

80-Meter notes—

Either the *BC-696* (3.0-4.0 Mc.) or the *BC-457* (4.0-5.3 Mc.) transmitter may be used for 80-meter operation. The dial of the *BC-696* is directly calibrated for the 80-meter band, but this advantage is outweighed by the high surplus price of this unit. Actually, the *BC-457* is much better suited to 80-meter phone operation than is the *BC-696*. The *BC-457* will actually cover the top 60 kc of the 80-meter phone band (3940-4000 kc) without any adjustment of the padding condensers. The L/C ratio of the BC-457 is also much more nearly correct for amplitude modulation of the p-a stage than is the *BC-696*. The *BC-457* tunes the 80-meter phone band with almost 350 $\mu\mu$fd. of tank capacity, whereas the *BC-696* tunes the same range with only about 150 $\mu\mu$fd. of tank capacity. Under heavy modulation, the *BC-696* tends to splatter badly, due to insufficient "flywheel" effect in the p-a tank circuit.

The *BC-457* may be easily shifted to cover the complete 80 meter phone band by increasing the capacity of *C-67*, the p-a padding condenser, and *C-60*, the oscillator padding condenser. The slug adjustments of the oscillator and p-a coils should not be changed, as this would alter the tracking of the transmitter.

40-Meter notes—

Either the *BC-459* (7.0-9.1 Mc.) or the *BC-458* (5.3-7.0 Mc.) may be used for 40-meter operation. The L/C ratio in the p-a tank of either transmitter is satisfactory for phone operation. The conversion of the *BC-459* is exactly the same as described for the *BC-696* on 80-meters (*Figure 20*).

The *BC-458* modification is the same as that of the *BC-459*, with the addition of retuning the tank circuits to make the transmitter tune the 7.0-7.3 Mc. range.

The *BC-458* oscillator can easily reach 7.3 Mc. by decreasing the capacity of *C-60*, the oscillator padding condenser. However, this is a poor approach, since it degrades the high C/L ratio of the oscillator. It is best to remove the oscillator coil shield and remove 4 turns from the top end of the oscillator coil. Next, loosen the set screws holding the rotor shaft of *C-60*. Drill a ¼" hole in the side of the shield can so that the shaft can be turned when the shield is replaced. Remove two plates from the rotor of *C-63*, the oscillator tuning condenser. Flex the plates gently with a long-nosed pliers. If too much force is applied to the condenser, the rotor will jump out of its bearings, and the minute ball bearings will fall out of the joint. Remove two rotor plates in the same fashion from *C-65*, the p-a tuning condenser. Loosen the rotor lock on *C-67*, the p-a padding condenser. Finally, remove four turns from the top of the p-a coil, *T-54A*.

Plate voltage should be applied to the 6J5 oscillator, and *C-60* and the slug of *T-53* adjusted until 7.0 Mc. falls at 6.0 Mc. on the tuning dial, and 7.3 Mc. falls at 6.3 Mc. Thus the

calibration will be correct if 1.0 Mc. is mentally added to the dial reading.

Plate and screen voltage should be applied to the p-a stage. The transmitter should be tuned to 7.2 Mc. and loaded to the antenna. The p-a padding condenser *C-67* should be resonated for minimum plate current and then locked. *C-65* should always be re-resonated whenever there is a major change in antenna loading or coupling.

Transmitter Conversion for 20, 15 and 10 Meters

The conversion of the 4.0-5.3 Mc. transmitter for high frequency use is based upon retaining single dial control and the use of one doubler stage.

The space left by the removal of the electron eye tube and the calibrating crystal may be used for a 6AG7 doubler and a slug tuned coil. The basic circuit for 20, 15 and 10 meters is shown in *Figure 22*.

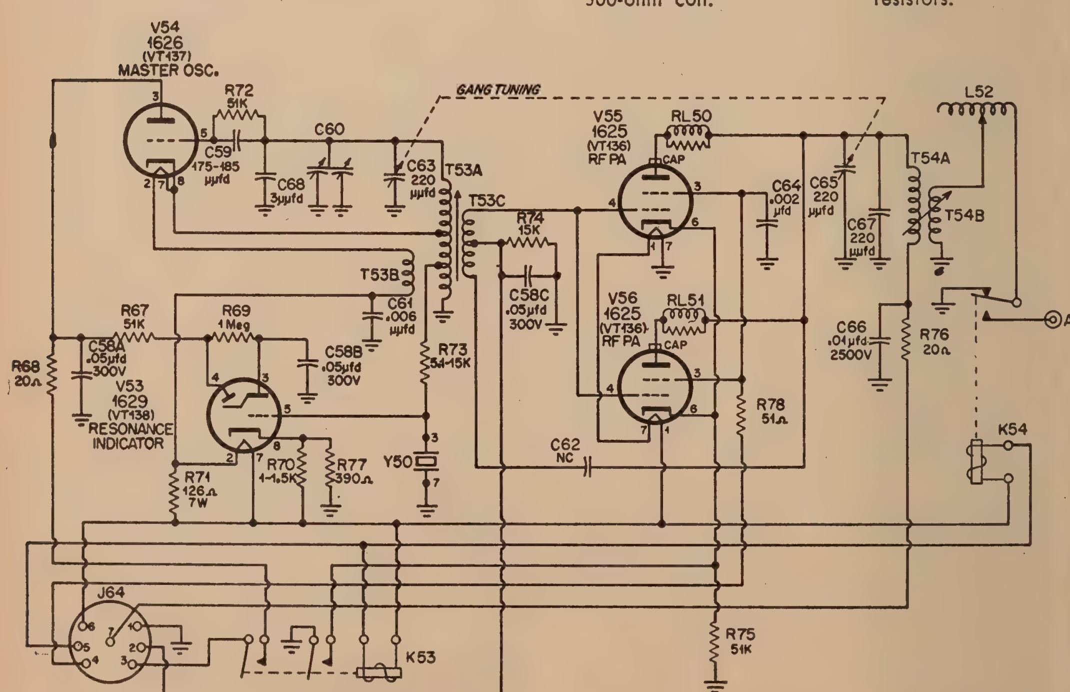
The basic filament and socket modifications as described for the low frequency units should be completed. For 20 and 15 meters, the 6J5 oscillator must work on the 7-Mc. band, using the existing dial calibration lines, with new figures. The main winding of the oscillator coil should be reduced to 12 turns, by removing turns from the *top* of the coil. The oscillator tuning condenser, *C-63*, should have all but two rotor plates removed. One of the remaining plates should be the slotted one for tracking adjustment.

At the oscillator coil terminals under the chassis, *C-62* (the neutralizing condenser) should be removed and the bias return of the doubler stage moved from the center tap of the coil to the free end.

An octal socket is placed in the crystal calibrator socket hole. The electron eye socket hole is covered by a small metal plate. A National *XR-50* slug tuned coil is mounted in the center of this plate with its slug adjustment above the chassis. This coil (*L1*) is wound with 10 turns of No. 24 enamelled wire, spaced to occupy the full winding length. Condenser *C16* con-

C-58—0.05/0.05/0.05 μfd., 300v.
C-59—175-185 μμfd.
C-60—air padder.
C-61—0.006 μfd., mica.
C-62—neutralizing condenser.
C-63, C-65, C-67—220 μμfd.
C-64—0.002 μfd., 1000v.
C-66—0.01 μfd., 2500v., mica.
C-68—3.0 μμfd., 750 p.p.m.
K-53—D.p.s.t. relay, 300-ohm coil.
K-54—S.p.d.t. antenna relay, 90-ohm coil.
R-67, R-75—51,000 ohms.
R-68, R-76—20 ohms.
R-69—1.0 megohm.
R-70—1000 to 1500 ohms.
R-71—126 ohms, 7w.
R-73—5100 to 15000 ohms.
R-74—15,000 ohms.
R-77—390 ohms.
R-78—51 ohms.
RL-50, RL-51—parasitic suppressors on 51-ohm resistors.

Fig. 18. This is a typical wiring schematic of the 274N series transmitters.



The "Command" transmitter and receiver, suitably modified, make a neat and compact under-dash mobile installation.

nects to the "hot" end of *L1* and is supported on its free end by a small ceramic standoff insulator. *C19* and *C18* mount directly on the 6AG7 socket. *C20* connects between the "cold" end of *L1* and the coil mounting lug. *RFC2* and the bias resistors mount on the side of the chassis, just about where *K-53* was located.

The p-a plate coil, *T-54,* is rewound with its own wire, using 5½ turns, double spacing them in the existing grooves. Remove all but two rotor plates from both the p-a tuning condenser, *C-65,* and the p-a loading condenser, *C-67,* The rotary antenna loading coil may be left in the circuit, but should be set at zero for coaxial feed.

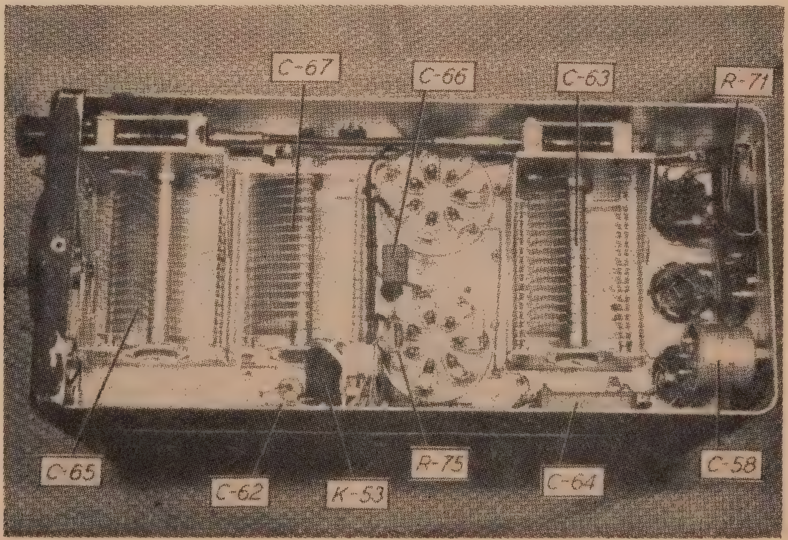
Power should be applied to the oscillator and doubler. *C-60* should be adjusted until the oscillator covers 7.0-7.2 Mc. The slotted plate in *C-63* may be adjusted until the range tracks with the dial markings, 14 Mc. falling at 4.0 on the dial, and 14.4 Mc. falling at 4.4 on the dial. Thus each dial division is equal to 5 kc at 20 meters.

Apply 250 volts to the screens of the 807's and the chosen value of plate voltage. Resonate the p-a tank circuit to 14 Mc. by tuning the padding condenser, *C-67,* under the chassis. Some slight adjustment of the p.a. slug in *T-54* may be necessary for perfect tracking. Peak the 6AG7 plate coil and replace the top and bottom shield plates.

For 15 meters, the 6AG7 stage operates as a tripler from 7-Mc. The coil, *L1* has 7 turns of No. 24 enam. wire spaced to occupy the winding length. For this band the ganged condenser, *C-65,* in the p-a stage is not used. All p-a tuning is done by *C-67,* the padding condenser. As in the case of 20 meters, *C-63* and *C-67* are reduced to two plates. *C-67* may be adjusted by a screwdriver thru the side of the case, or an extension shaft and knob may be placed on it. The p-a coil, *T-54,* is rewound to 4 turns, double-spaced located near the center of the coil form for best coupling to the variable link inside the ceramic form.

For 10 meters, the 6J5 oscillator is brought to 14 Mc., and the 6AG7 operates as a doubler to 28 Mc. The stability of the oscillator is still very good at this high frequency.

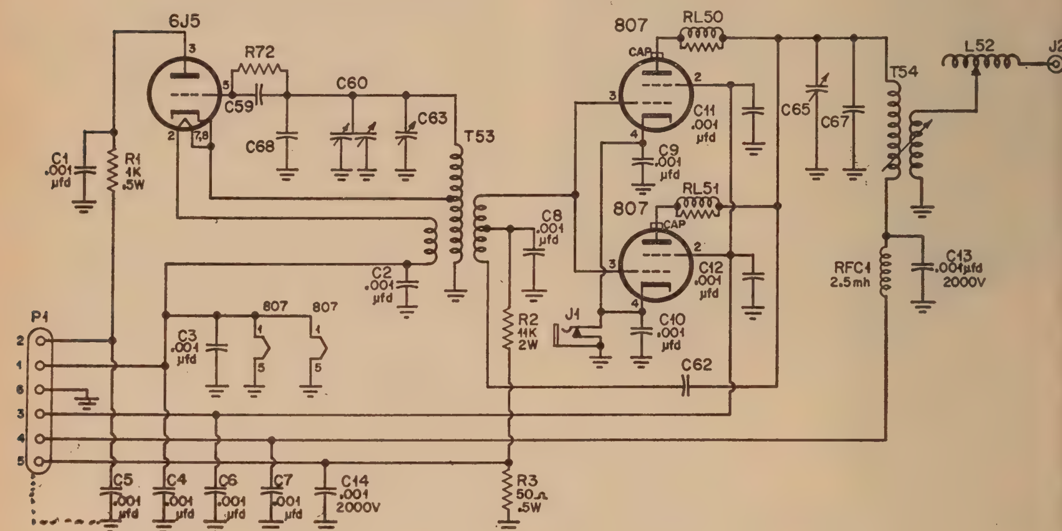
These modifications are made as for 20 meters: The doubler coil consists of 5 turns of No. 24 enam. wire on the *XR-50* form. The oscillator coil, *T-53* is modified as follows: Remove turns from the top of the coil, leaving 1 2/3 turns above the cathode tap. Remove turns from below the cathode tap, leaving only 4 turns below the tap. Be careful not to damage



ig. 19. Bottom view of a ypical Command type war urplus transmitter showing ie location of some of the nportant components.

Fig. 20. Transmitter modification to either 20 or 40 meters. Step-by-step details appear on page 107. All components without a parts value are the same as shown in Fig. 18.

C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C15—0.001 µfd., ceramicon, Erie 801-001.
C13, C14—0.001 µfd., ceramicon, 2000wv.
R1—1000 ohms, ½w.
R2—11,000 ohms, 2w.
R3—50 ohms, ½w.
J1—jack, closed circuit, ICA 1871.
J2—coaxial connecter, Amphenol 83-1R.
P1—socket, Amphenol 86-CP6.
RFC1—2.5 mh, National R-100U.



the filament winding interwound with the grid coil. Remove 4 turns from the bottom of the filament winding. This should be done by cutting a turn, removing turns, then splicing the wires together again. Remove all but 3 rotor plates from the oscillator tuning condenser, *C-63,* and all but 7 rotor plates from the oscillator padding condenser, *C-60.*

The plate coil, *T-54,* must be removed for 10 meter operation. A new coil, consisting of 5 turns of No. 12 enamelled wire, 1″ long and 1″ diameter is wound on a Millen 45000 coil form, which is bolted to the chassis in front of the 807's, in approximately the location of the old coil.

The ganged p-a tuning condenser, *C-65,* is unused. The padding condenser, *C-67,* is cut down to *5 rotor and 6 stator plates* and used as the tuning condenser for the new coil. Its shaft may be extended thru the side of the case, if desired, or it may be screwdriver tuned and locked. The small parasitic suppressors should be removed from the old coil and reused in the 807 plate leads.

An antenna link should be wound consisting of 3 turns of No. 12 enamelled wire, 1¼″ diameter and should be mounted on standoff insulator to slip over the plate coil. Once adjusted for proper loading, it may be fixed in position and left alone. For ease of loading, a 100 µµfd. variable condenser should be placed in series with the antenna coil.

Apply plate voltage to the oscillator and doubler and adjust the oscillator to 14.5 Mc. by listening on the station receiver. The doubler should be then tuned to 29 Mc. It is simpler in this case to disregard dial markings, and recalibrate the whole dial once the oscillator has been adjusted. Apply plate and screen voltage to the 807's and tune the p-a tank to resonance. Replace the top and bottom shields, peak up the doubler, check the oscillator frequency and calibrate the dial from 28.0 Mc. to 29.7 Mc. The conversion is now complete.

The Modulator

The command transmitters described above will perform in an excellent manner with a plate supply of 500 to 600 volts. Using a surplus PE-103A dynamotor, they are capable of an input of 60 watts to the final amplifier, with 100% modulation. From a fixed location using a plate supply of 600 volts at 200 ma., they are capable of 100 to 120 watts input.

The modulator described here will fully modulate up to 120 watts input to the transmitter. At the same time, it is economical for use with inputs as low as 30 or 40 watts, since the static plate current is lower than that of a single 6N7 tube, and only about one third the static plate current of a pair of Class AB1 6L6's.

The modulator employs a pair of triode connected zero-bias 807 tubes, driven by a push-pull 6SN7 cathode follower (*Figure 24*). The screens and grids of the 807's are connected

Fig. 21. The 1625 sockets must be modified for use with 807 tubes. This is done by filing holes to sockets terminals 2, 4 and 6 so that they will accept the 807 pins.

together thru a 22,000 ohm resistor and the drive is applied to the screen grids of the tubes. The static plate current is of the order of 8 ma. with this connection, but the cathode coupled driver supplies a positive grid bias of 10 volts to the 807's which raises the static plate current to 30 mills. This will increase to 80 to 150 ma. with tone modulation depending upon the amount of audio required. On voice, the average plate current peaks as read on the plate meter will run about 120 ma. for full output.

The necessary low impedance driving stage is supplied by the 6SN7 cathode follower. The total plate current required by the two driver tubes is less than 10 ma. at 250 volts. This may be obtained from a dropping resistor from the high voltage supply, or perhaps from the receiver plate supply, which may be switched from the receiver to the modulator during transmissions.

The plate to plate load of the modulator should be about 12,000 ohms, although the modulator will work well with plate loads as low as 4000 ohms. No change in plate impedance or bias is necessary with operating plate voltages in the region of 150 to 600 volts.

The entire modulator may be built on a stripped down SCR-274N chassis. The 1625 sockets may be modified to take 807 tubes, and the speech amplifier tubes may be mounted in the socket holes at the rear of the chassis. *T1* may be mounted beneath the VFO shield can. *Figure 23* shows the modulator mounted in a command rack with a modified transmitter, and *Figure 25* illustrates the placement of parts within the modulator unit.

A patch plate covers the top portion of the front panel, and mounts a 0-300 ma. meter which may be switched to read either modulator plate current or the final plate and screen current of the transmitter.

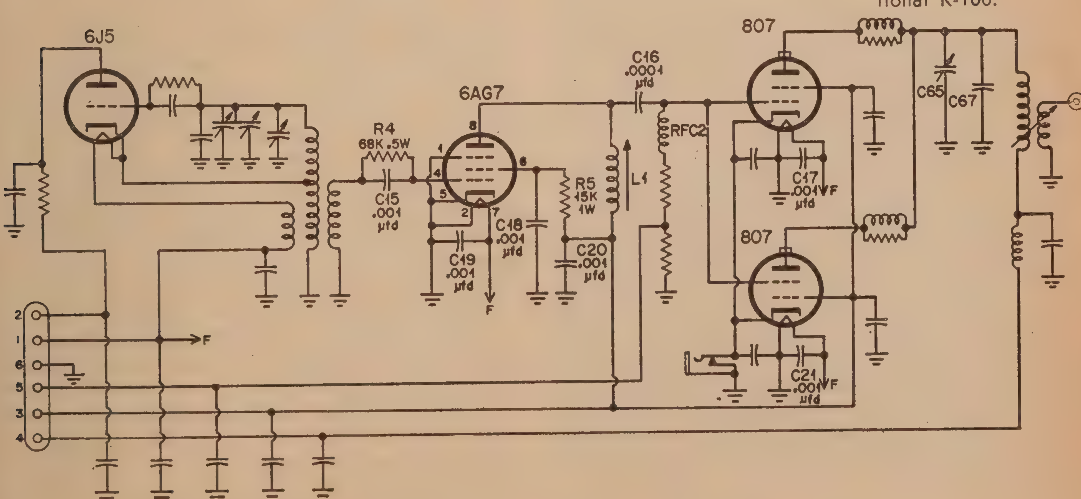
The gain control, *R6*, is mounted near the rear sockets on a small bracket and is provided with an extension shaft to make it accessible from the front panel. A "Filament" and a "Transmit" pilot lamp may be mounted above the meter, if desired.

Control Circuits

A typical control circuit for use of this modulator, with a "Command" transmitter and a *PE-103A* dynamotor is shown in *Figure 25*. This circuit may easily be modified for use with other power supplies, if desired, by removal and substitution of the *PE-103A* power plug, as shown.

Fig. 22. To modify the Command transmitter to operate on 20 meters and below an extra doubler stage is required.

C15, C17, C18, C19, C20—0.001 µfd., ceramicon, Erie 801-001.
C16—0.0001 µfd., ceramicon.
L1—at 14 Mc., 10 turns #24 enam., ½-inch long on XR-50.
at 21 Mc., 7 turns #24 enam., ½-inch long on XR50.
at 28 Mc., 5 turns #24 enam., ½-inch long on XR-50.
R4—68,000 ohms, ½w.
R5—15,000 ohms, 1w.
RFC2—2.5 mh., National R-100.



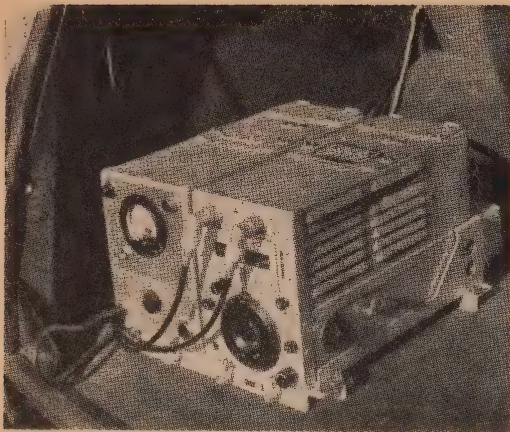


Fig. 23. Modulator for "Command" transmitter may be built into stripped transmitter chassis and mounted in double rack as companion unit to transmitter.

the "Command-phone"

A unique modification of a "Command" transmitter is shown in *Figures 26, 27* and *28.* Designed and built by William Buffinger, W6BRH, this modified 274N transmitter incorporates the modulator and speech amplifier on the r-f chassis, providing a complete 50-watt phone transmitter that may be used for mobile or fixed operation on either the 80 or 40 meter phone band.

As shown in the schematic *(Figure 27),* the transmitter may be employed on either a 6- or 12-volt primary source by the proper choice of tubes in the r-f section. For 12-volt operation, a 1626 is used as the v.f.o., and a 1625 as the class C amplifier. For 6-volt operation, a 6J5 is used as the v.f.o. tube, and an 807 as the class C amplifier. When the 807 tube is used, the tube socket for it must be modified as shown previously in *Figure 21.*

The same tubes are used in the audio section of the transmitter for either 6- or 12-volt operation, the filament connections merely being altered as shown in *Figure 27.* For 6-volt operation, the filaments of the two 6SN7 tubes are connected in parallel, and the two 5881 modulator tube filaments are also connected in parallel. For 12-volt operation, the 6SN7 tube filaments are connected so that the filaments of each tube are in series, and the filaments of the two 5881 tubes are connected in series.

Room for the complete audio section of this transmitter is obtained by removing the "magic eye" tube, the crystal calibrator, and one of the two parallel connected 1625 tube sockets. The two 6SN7 tubes are placed in the "magic eye" and crystal calibrator sockets, and the modulation transformer, *T4,* is mounted over the hole left by the removal of the 1625 tube socket assembly. The original plate tank coil is removed, along with the antenna loading coil to make room for the two 5881 modulator tubes and the plate current meter of the 807 stage. The loading coil is rewound to form a new plate coil for the 807 tube, and mounted as shown in *Figure 26.*

The transmitter is designed to work from a PE-103A, a modified PE-104A dynamotor or a dual voltage vibrator supply. Total plate current drain under 100% modulation is approximately 250 milliamperes at 500 volts. Power input to the 807 is 50 watts. At a reduced voltage of 300 volts the transmitter is capable of 20 watts input, and total plate current drain under 100% modulation is approximately 200 ma.

The Circuit

A complete schematic for the modification is shown in *Figure 27.* For 80-meter operation, either a *BC-696* or a *BC-457* (or the JAN or Navy equivalent units) may be used. For 40 meters, a *BC-459* or a *BC-458* (or the JAN or Navy equivalent) may be used. The modifications to these transmitters that are necessary to make them tune the proper frequency have been discussed earlier in this chapter.

The neutralizing circuit of the original transmitter is not needed, and the oscillator coil, *T53,* is modified to permit full excitation to be applied to the 807 stage. The center-tap of the coil is disconnected from the bias circuit, and the neutralizing condenser, *C62,* is disconnected from the coil. The grid bias network is then connected to the coil tap that previously was connected to *C62.*

A pi-network output circuit is used in place of the link coupling arrangement in the original transmitter circuit. *C65,* (the tuning condenser nearest the front of the chassis in *Figure 19)* is used as the plate tuning control, and *C67,* (the condenser immediately behind *C65)* is used as the antenna loading control. Additional fixed capacity *(C1)* may be paralleled across *C67* to allow proper loading of the transmitter when low impedance antennas are employed. This extra capacity may be a 1250 volt mica condenser of the correct value. Such a condenser is shown mounted directly behind the antenna changeover relay in *Figure 26.*

The modulator is patterned after the triode connected 807 modulator of *Figure 2.* It is necessary to employ the stubby 5881 tubes since taller tubes, such as the 807 or 6L6 will not fit in the space allotted to the modulator tubes. These tubes cannot be mounted in sockets that sit flush with the deck, since the below-deck space is taken by condensers *C65* and *C67.* It is therefore necessary to bend a small chassis from a piece of aluminum that will mount the

modulator tube sockets above the chassis of the transmitter. Enough space must be left between the small chassis and the transmitter deck to allow clearance for the modulator socket pins. The 5881 tubes fit nicely into the rather cramped vertical headroom that is left between the auxiliary chassis and the top of the transmitter cabinet. For all practical purposes, the 5881 tubes may be considered to be electrical equivalents of 6L6-G tubes.

The normal negative bias requirements of modulator stages of medium power capabilities may be eliminated if the tetrode tubes are connected as zero bias triodes, with the audio signal fed directly to the screens of the modulator tubes. For proper linearity, series resistors are inserted in the grid leads to the tubes to provide the proper ratio of exciting voltage to the two grids.

A single double triode tube such as a 6SN7 may be used as a cathode coupled driver stage, providing ample excitation while yet allowing the use of a low impedance driving source for the modulator grid circuit. This cathode coupled driver stage is degenerative in that it requires a considerable amount of grid driving voltage for proper operation. Two stages of transformer coupled speech amplification will provide sufficient excitation when the usual high level carbon microphone is employed. The actual modulation level is set by the gain control, *R1*, in the grid circuit of the second half of the 6SN7 speech amplifier.

A three circuit microphone jack, *J1*, is provided for "push-to-talk" operation of the transmitter. When the microphone button is pushed, the control line is grounded, energizing the antenna relay in the transmitter, and the power supply relay that is used to put the equipment on the air.

Transmitter Assembly

The first step is to remove the unused components from the transmitter chassis. The shell-type socket for the unused 1625 may be removed by turning up the exposed edge with the aid of a screwdriver or cold chisel. The shell is soft aluminum, and the edge may easily be bent to facilitate removal.

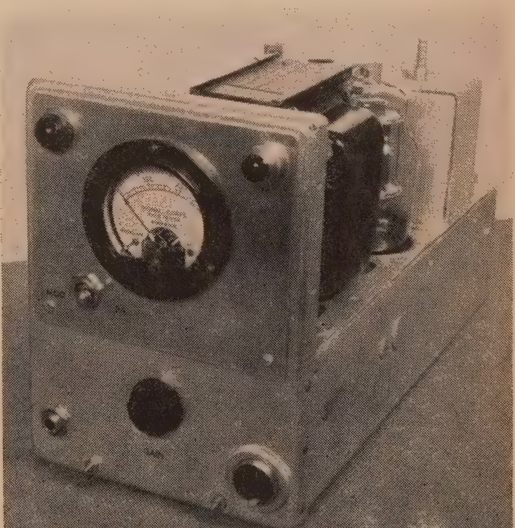
The aluminum plate holding the 5881 tube sockets may be observed in *Figure 26*. It is 4½″ long, and 2″ wide. The tube sockets are mounted on this plate, which is elevated above the transmitter chassis one inch. The placement of the tubes on this plate is dictated by the depth of the panel meter. The tubes should be mounted as close to the meter studs as is practical. A space of about 3″ by 2¾″ is available for the modulation transformer. A *Stancor A-3845* 25-watt modulation transformer will fit into this space. Doubtless other transformers of the same audio level rating will work equally well.

The microphone transformer, *T1*, used in this particular transmitter is a surplus unit, and is equivalent to the *Triad type JO-1* unit. This transformer is mounted to the side wall of the transmitter chassis, directly "above" the 6SN7 audio amplifier tube socket. On the opposite side of the chassis are mounted the audio gain control, *R1*, and the three circuit microphone jack *J1*. These two units project out the side of the chassis, as seen in *Figure 28*. Directly behind *J1* is the interstage audio transformer, *T2*, mounted to the rear wall of the chassis, directly "above" the power receptacle. The driver transformer, *T3*, is mounted below the chassis in the space vacated by the 1625 tube socket. (This transformer was removed for the photo of *Figure 28)*.

The shaft of *C67* is lengthened by means of a shaft coupler *(Bud S-1052)* and may be controlled by a knob from the side of the transmitter. The large gear of *C65* is removed, and the shaft of this condenser is lengthened in the same manner as that of *C67*. The main tuning dial of the transmitter now tunes only the v.f.o., and the amplifier resonance setting is now controlled from the side of the transmitter by means of *C65*. Placement of all the side controls may be seen in *Figure 28*.

The plate circuit of the 807 stage is shunt-fed via a 2½ mh. r-f choke *(National R-100)*, and a .001 μfd. ceramic 2000-volt condenser is used as a plate blocking unit to remove the d-c voltage from the pi-network components. The r-f choke is fastened between one unused pin on the 1625 socket and a ceramic feed-through insulator leading to the top of the chassis. The plate blocking condenser is mounted between this feedthrough insulator and one terminal of the pi-network coil, *L1*.

This plate coil is made from *L52*, the old antenna loading coil. This particular transmitter was made from a *BC-696* which employed



The modulator of Figure 24 built into the case of a "Command" transmitter.

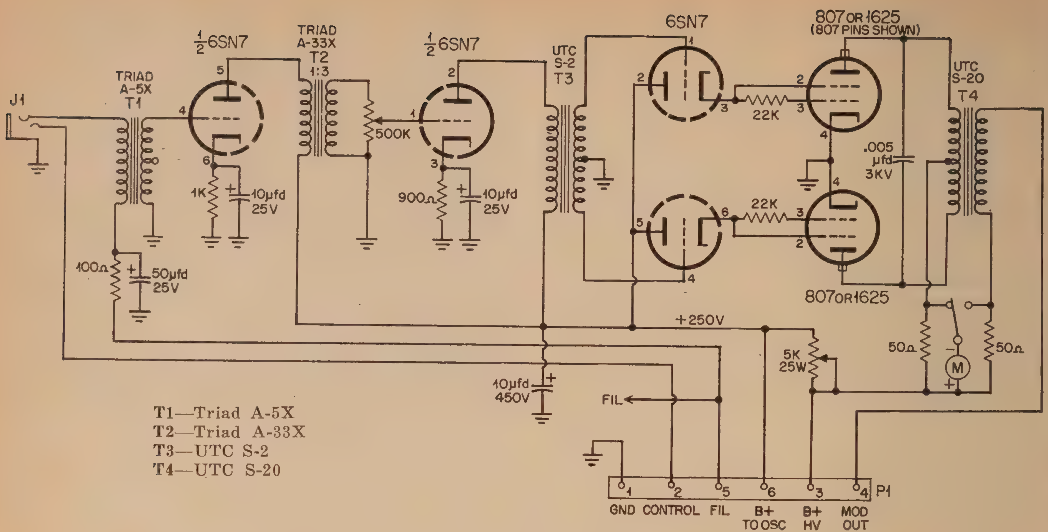


Fig. 24. Mobile modulator for "Command" transmitter.

a loading coil marked *6033*. 12 turns were removed from this coil, along with the metal axles at each end. The coil was then mounted in a vertical position on the chassis by means of two mounting feet removed from the old tank coil. The end of the coil nearest the chassis is the "hot" end that is attached to the plate blocking condenser.

The *BC-457* transmitter employs a loading coil marked *6034*. This coil has less inductance than the coil of the *BC-696*. It will be necessary to resonate the pi-network circuit after completion of the transmitter to determine how many turns (if any) must be removed from this coil to obtain resonance of the plate circuit in the 80-meter band.

An *Advance Electric Co.* ceramic insulated type *K-1604* relay is mounted to the rear of the front panel of the transmitter to serve as an antenna change-over relay. The relay may be obtained with either a 6-volt coil, or a 12-volt coil as required. Above the relay, two terminals are mounted to serve as the antenna and ground connections for the transmitter. Connection to the antenna circuit of the mobile receiver is made via a short length of RG-59/U coaxial line that is brought out the side of the transmitter near the change-over relay. This line is terminated in an auto-type plug that matches the input jack of the converter.

Transmitter Operation

As a first step, the 1626/6J5 oscillator tube should be inserted in its socket, and the v.f.o. should be aligned and calibrated. The 807/1625 tube may be inserted in its socket, and the grid current should be measured *before* plate or screen voltage are applied to the tube. This current should be 4 ma. The plate dropping resistor in the plate lead of the oscillator may be varied in value to obtain the correct amount of grid current in the p-a stage. The plate voltage may now be applied to the 807 stage, which is then loaded to a suitable antenna. When a loaded resonant whip is used, the value of the condenser shunting *C67* will be of the order of .001 μfd. or more.

The four audio tubes may now be inserted in their respective sockets. Under 100% modulation, the plate current of the 5881 tubes will increase to approximately 100 ma. as measured by a meter temporarily placed in the B-plus lead to the center-tap of the modulation transformer.

Transmitter Power Supply

If a power supply is to be purchased to run the transmitter, the new *Cornell-Dubilier "Powercon"* vibrator supply is ideal. This compact unit supplies 500 volts d-c at a current of 225 ma., and 250 volts d-c at 225 ma., and operates from either a 6- or a 12-volt primary source. Since both output voltages are delivered simultaneously, the 250 volt output may be employed to power the v.f.o. and the speech stages, while the 500 volt output is used to power the modulator and the 807 p-a stage.

Other acceptable power supplies are the PE-103A and PE-104A dynamotors. If these are used, a voltage dropping resistor must be employed to drop the high voltage output of the dynamotor to 250 volts for the low power stages of the transmitter.

A highly satisfactory vibrator supply that is well suited for use with this transmitter is the new *James C-1050* mobile power pack. This unit will supply various voltages in the range of 150 to 500, at a current rating of 200 ma. The supply may be obtained in kit form, for greatest economy.

The vibrator supplies are recommended over the dynamotor supply since no dropping resistors are required, and the higher efficiency of the vibrator supply imposes less drain upon the automobile power system.

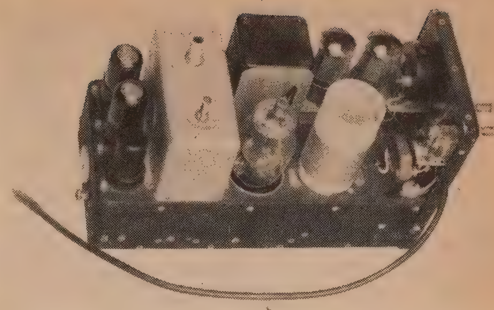


Fig. 26. The "Command-Phone." This modified Command transmitter incorporates a class-AB modulator and delivers a fully modulated 30-watt carrier. Both r-f and audio sections are mounted on the one chassis.

the Simplex-28

During the next few years, the ionization of the various reflecting layers above the surface of the earth will be heavy enough to support communication over great distances on the 10-meter band. Most of the amateurs licensed in the last decade have had little experience with mobile operation when the 10-meter band is "hot". Tremendous distances may be covered using simple mobile equipment and an eight-foot whip antenna. No auxiliary loading coils are needed to resonate the usual eight foot whip in the 10-meter band, and the complete mobile installation may be light, compact and inexpensive.

For the beginner who desires to get the most for his money, a simple transmitter capable of working from either a 300 volt, 100 ma. vibrator supply, or perhaps a 300 volt, 150 ma. dynamotor is the best answer to the problem of inexpensive 10 meter mobile equipment. The transmitter should be fool-proof, easy to assemble without the need of special tools, and should use inexpensive components operating well within their maximum safe ratings.

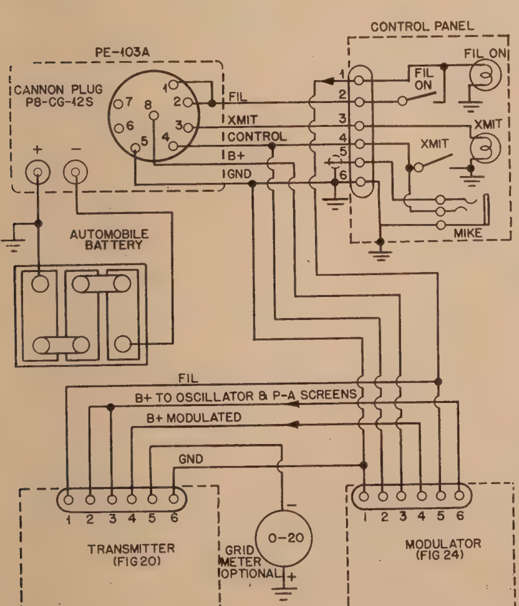


Fig. 25. Control circuit for "Command" transmitter for use with PE-103A dynamotor.

Illustrated in *Figures 29, 30* and *31* is the *Simplex-28* transmitter, designed to meet these requirements. It is small in size, yet not small enough to make its assembly a difficult procedure. It is capable of a maximum power input of about 20 watts, but will operate efficiently at inputs as low as 10 watts. It may be used with either a vibrator-type power supply or a dynamotor. Since the transmitter is designed for one band operation, expensive coil switching arrangements may be eliminated. By proper design, the harmonic content of the transmitter is kept to a satisfactory minimum, allowing operation of the mobile equipment in areas of low TV field strength.

The Circuit

The schematic of the *Simplex-28* is shown in *Figure 29.* A 6AG7 high-conductance pentode is used in a modified "tri-tet" oscillator circuit. The cathode circuit of the oscillator is tuned to approximately 10.5-Mc. for proper operation of the transmitter with a 7-Mc. crystal. The L/C ratio of the cathode tank is chosen for maximum harmonic output consistent with minimum crystal current. The plate circuit of the 6AG7 stage is tuned to 28-Mc. by means of a slug-tuned coil, *L1.* This coil is resonated to the 28-Mc. band by the residual input and output capacities of the 6AG7 and 2E26 tubes. The oscillator delivers sufficient output at a plate potential of 300 volts to drive a pair of 2E26 tubes in parallel at 28-Mc.

The harmonic oscillator is capacitively coupled to a single 2E26 tube operating as a class C amplifier on the 10-meter band. The plate circuit of the amplifier stage employs a pi-section network, matching the relatively high impedance of the plate circuit of the 2E26 tube to either a 50 or 72 ohm coaxial transmission line. A simple single section harmonic filter is placed after the pi-network to provide some degree of attenuation to the higher harmonics of the transmitter.

A "tune-transmit" switch is placed in the

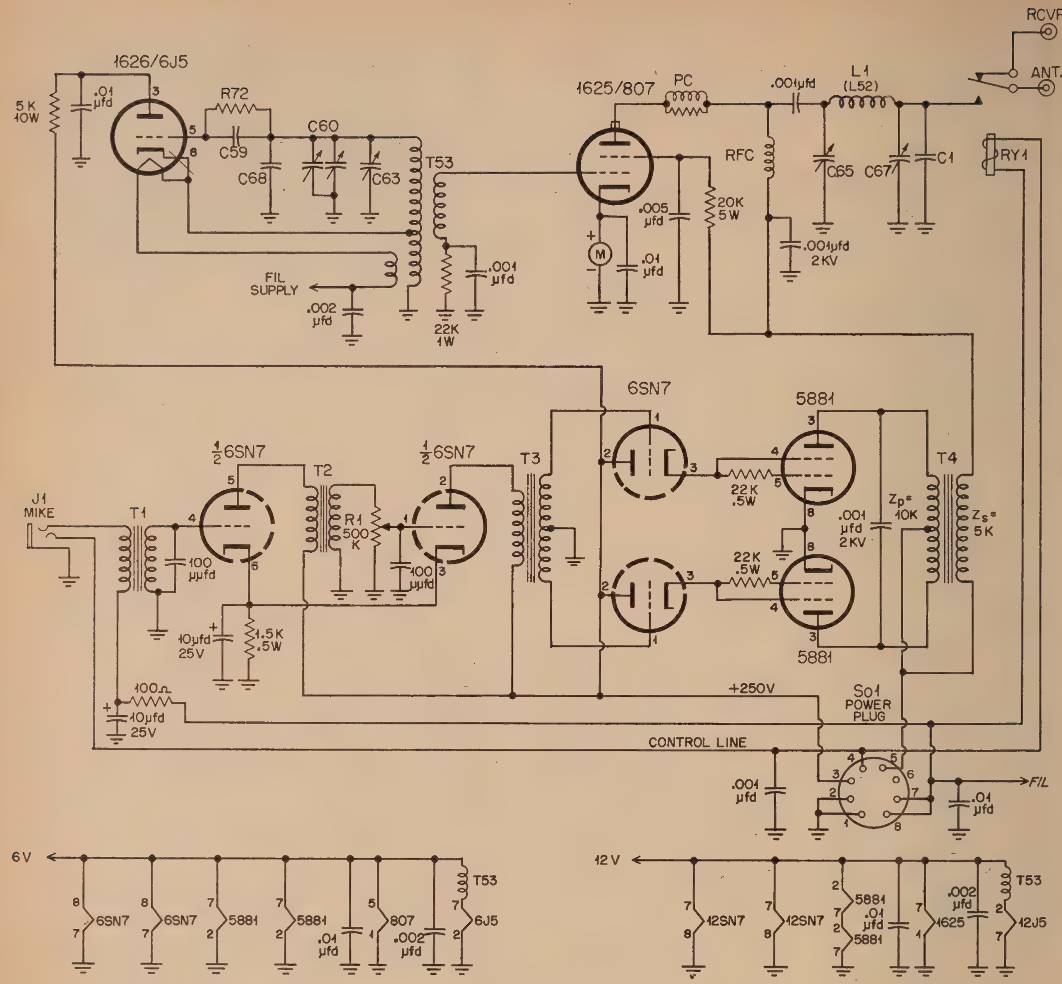


Fig. 27. Schematic of "Command-Phone" transmitter.

C1—Auxiliary loading condenser. Capacity determined by test. Use 1250 volt mica unit

SO1—8 prong octal plug

Note—All bypass condensers are ceramic units similar to Centralab type DD.

R1—500,000 ohm potententiometer. Linear taper

T1—Miniature microphone transformer. Triad JO-1

T2—Interstage transformer; 1:3 ratio. Triad A-31X

T3—Interstage transformer, heavy duty. Triad A-33X

T4—25 watt modulation transformer. Stancor A-3845 — 10,000 ohm primary to 5000 ohm secondary

RY1—DPDT ceramic insulated relay, 6 or 12 volt coil. Advance Electric Co. type K-1604

PC—Parasitic choke. 50 ohm 2 watt composition resistor wound with 5 turns #22e. wire

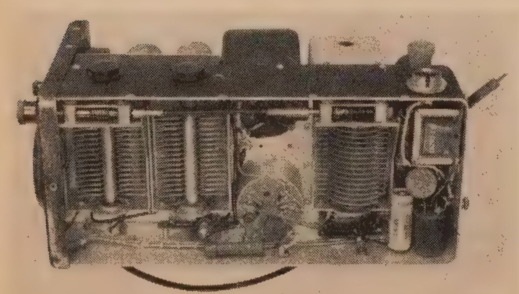


Fig. 28. Under chassis view of "Command-Phone." Antenna loading and p-a tuning controls are visible at the upper left of the chassis. Microphone jack and audio gain controls are at upper right. Transformers *T1* and *T2* are mounted behind the oscillator tuning condenser, *C60*.

screen circuit of the 2E26 stage. In the "tune" position, screen voltage is removed from the amplifier tube, allowing adjustments to be made to the 6AG7 stage without fear of damage to the 2E26. In the "transmit" position, full screen voltage is applied to the 2E26. The cathode current of the amplifier stage may be measured by means of a 100 ma. meter plugged into the cathode jack, *J1*, of the 2E26.

The modulator stage employs a single 6V6-GT, operating in extended class A condition. A high gain microphone transformer couples the output of a carbon microphone into the control grid of the 6V6-GT. Voltage for microphone operation is taken from a tap on the cathode bias resistor of the modulator tube. The 6V6-GT modulator is coupled to the 2E26 amplifier stage by means of a *Triad M-4Z* modulation reactor. A step-up in impedance is obtained between the two stages, allowing 100% modulation of the 2E26 although it is operated at the same plate potential as is the 6V6-GT modulator. Since the instantaneous plate voltage of the modulator never swings to zero, it is practically impossible to cause negative peak clipping of the 2E26 stage. As a result, the modulation of the transmitter is clean and sharp, and unusually free of the sideband "splatter" that so often accompanies mobile transmitters.

When the transmitter is operated at a plate potential of 300 volts, a measured 6 watts of *sine wave* audio may be obtained from the modulator. Under *voice waveform* conditions, with tolerable distortion, the 6V6-GT is capable of 90% modulation of inputs to the 2E26 of 20 watts or so. This is entirely sufficient for acceptable mobile work, as the actual opera-

Fig. 29. Schematic of the Simplex-28.

C1—50 uufd. Bud LC-1642

C2—50 uufd. Bud LC-1646

C3—Auxiliary padding condenser 50 uufd. mica, if used

L1—11 turns #22e wire on National XR-50 form ½" diam, ¾" long

L2—8 turns #16e, 1⅛" diam. 1" long. (#808T Air-dux) B&W #3014

L3—7 turns #16e, 1" diam, ½" long. (B&W #3015) Air-dux 816T

L4—3t #22 d.c.c. wound around 100 uufd mica condenser

L5—8 turns #22 d.c.c. wound around 1 meg., 1 watt resistor

RFC1—2½mh. National R-100u

SO-1—5 prong octal plug

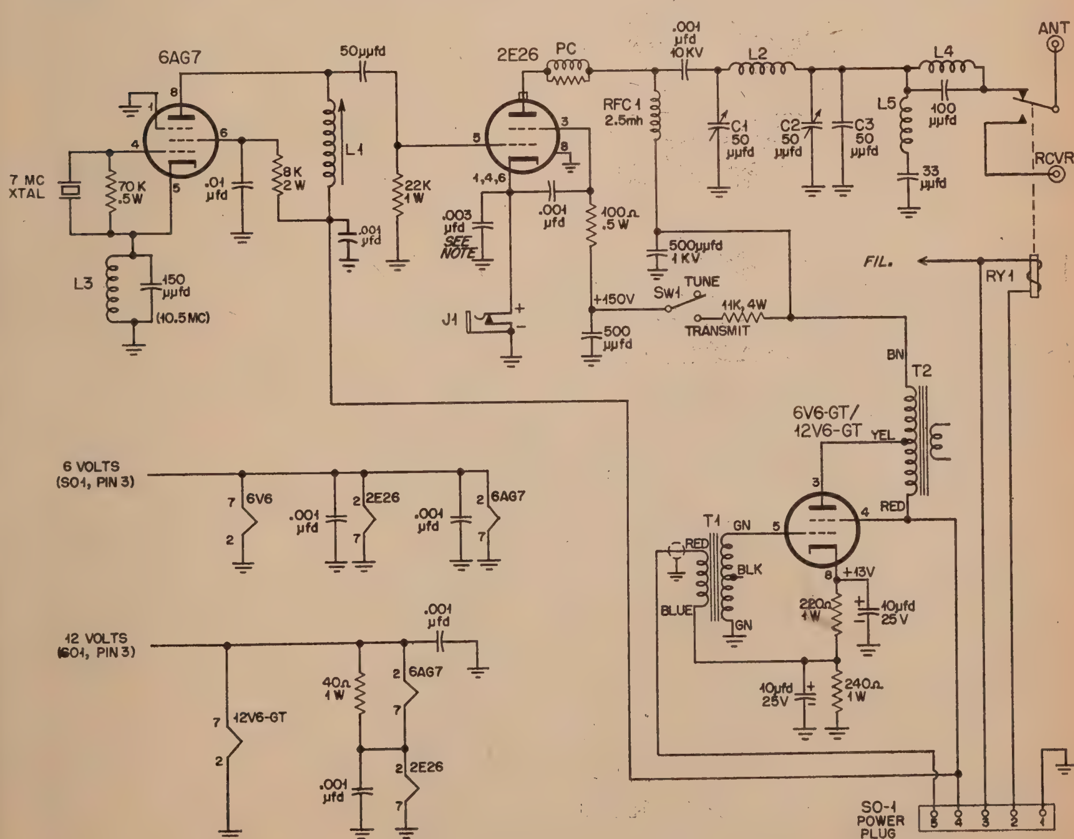
T1—High gain microphone transformer. Triad A-5X

T2—Modulation reactor. 5000 ohms. Triad M-4Z

RY1—DPDT relay, 6 or 12 volt coil. Advance Electric Co. type K-1604.

PC—3t #16e on 50 ohm 2 watt composition resistor

Note—Each cathode pin of the 2E26 is bypassed to ground with a single .001 ufd ceramic condenser



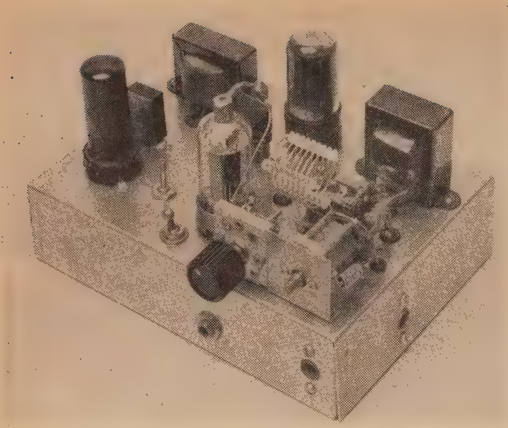


Fig. 30. The Simplex-28 transmitter. Running 15 watts input, this inexpensive 28-Mc. phone transmitter may be powered from a 100 ma vibrator-type power supply. Only 3 tubes are needed in this sure-fire circuit. TVI suppression measures are included in the transmitter.

tion of the transmitter has proved many times.

The transmitter is designed to work with an auxiliary control unit, such as shown in *Figure 32*. The microphone jack is incorporated in the control unit, so the microphone wires are brought out through the transmitter control plug, *SO-1*. The control lead for the antenna changeover relay is also brought out through *SO-1*.

Transmitter Assembly

The above-chassis parts layout of the transmitter may be seen in *Figure 30*. A 8″ x 6″ x2″ aluminum chassis is used. The 6AG7 oscillator tube is mounted in the left front corner of the chassis, with the crystal holder directly behind the tube. At the rear of the crystal holder is the microphone transformer, *T1*. To the right of *T1* is the socket for the 6V6-GT modulator. This socket is oriented so that the "key" of the tube faces the front of the transmitter. To the right of the 6V6-GT is the modulator reactor, *T2*. The leads to both *T1* and *T2* pass through the chassis in ¼″ rubber grommets.

To the right of the 6AG7 oscillator tube socket is mounted the oscillator plate coil, *L1*. The 6AG7 socket is positioned so that *pin #1* is adjacent to coil *L1*. To the right of *L1 is* mounted the socket for the 2E26 tube. This socket is positioned so that *pins # 4* and *5* are adjacent to *L1*. The spacing between these two tube sockets is 3¼″. *L1* is mounted half-way between the two sockets.

To the front and side of the 2E26 socket is mounted *S1*, the "tune-transmit" switch. To the right of the 2E26 socket are mounted the two tuning condensers for the pi-network. The input resonating condenser, *C1*, is mounted adjacent to the 2E26, and the output loading condenser, *C2*, is mounted at the right of *C1*. In this particular transmitter, *C1* is a *Bud LC-1642* which has an aluminum mounting foot. *C2* is a *Bud LC-2018* midget screwdriver-adjustment type condenser which requires some kind of mounting attachment. It would be better to use a *Bud LC-1646* for *C2*, as this unit has a mounting bracket similar to *C1*. Since the rotors of these condensers are "floating", it is necessary to ground each rotor connection of *C1* and *C2* directly to the chassis of the transmitter.

Behind the 2E26 tube is the plate r-f choke *(National R-100U)* and the antenna changeover relay *(Advance type K-1604)*. The leads to the changeover relay pass through ¼″ rubber grommets mounted in the aluminum chassis.

On the front lip of the chassis are mounted the closed-circuit cathode jack, *J1*, and the coaxial receptacle for the antenna. The coaxial receptacle for the receiver is mounted on the side of the chassis, directly below the antenna relay.

The placement of parts below the chassis may be seen in *Figure 31*. The cathode circuit is mounted between one prong of the crystal socket and pin *#1* (ground) of the 6AG7 tube. The two cathode resistors and electrolytic condensers making up the bias circuit of the 6V6-GT tube are mounted on phenolic tie point strips adjacent to the modulator tube socket. The 500 $\mu\mu$fd. ceramic plate bypass condenser in the 2E26 B-plus lead is mounted on a two point phenolic tie strip adjacent to the rubber grommet that conducts the lead from the plate r-f choke above the chassis to the modulation reactor, *T2*.

Transmitter Wiring

1—After all main components are mounted to the chassis, certain pins of each tube socket should be grounded. *Pins 1* and *7* of the 6AG7 socket should be grounded, as well as *pins 7* and *8* of the 2E26 socket, and *pins 1* and *2* of the 6V6-GT socket. *Pin 2* of the 6AG7 socket and the 2E26 socket should be bypassed to ground by a .001 ceramic disc-type condenser. The above connections are for 6-volt operation of the filaments.

2—For 12-volt filament operation, *pins 7* and *8* of the 2E26 are grounded, as well as *pin 2* of the modulator socket. A 12V6-GT is used in the modulator stage instead of the 6-volt version. The 6AG7 and 2E26 are connected in series as shown in *Figure 29. Pin 1* of the 6AG7 is grounded, and *pin 7* of this tube socket connects to *pin 2* of the 2E26 socket. The 12-volt filament line connects to *pin 2* of the 2E26, and a 40 ohm, 1-watt resistor is connected between *pins 2* and *7* of the 6AG7 socket. This resistor equalizes the current drawn by the two tubes. *Pin 2* of the 6AG7 socket and *pin 2* of the 2E26 socket are bypassed to ground by .001 ceramic condensers.

3—After the filament connections are finished,

the screen and cathode bypass condensers are connected to the respective socket pins. On the 6AG7 socket, a .01 μfd. ceramic condenser is connected between *pin 6* (screen) and ground *(pin 1)*. The 2E26 tube has three cathode terminals *(pins 1, 4,* and *6)*. Each of these pins is bypassed to ground by means of a .001 μfd. ceramic condenser connected between the respective pin and the nearest grounding "ear" on the tube socket. The condenser leads should be cut as short as possible. The amplifier screen bypass condenser connects directly between *pin 3* and *pin 4* on the 2E26 socket. The 100 ohm screen resistor is placed between *pin 3* of the 2E26 socket and one terminal of *S1*. The 500 μμfd. screen bypass condenser is placed between the arm of *S1* and *pin 7* (ground) of the 2E26.

4—The *70K* grid resistor of the oscillator tube is placed across the pins of the crystal socket. The .001 μfd. ceramic condenser at the "cold" end of *L1* is connected between the lower terminal of the form and the grounding lug of the form. The screen resistor of the oscillator is connected from *pin 6* of the tube socket to the lower terminal of *L1*.

5—The cathode tank of the oscillator is made of 7 turns of *B&W Miniductor* or *Air Dux 816T*. (1" diameter, ½" long, #16 wire). A 150 μμfd. silver mica condenser is connected across the ends of the coil, which is placed between one pin of the crystal socket and a grounding "ear" of the 6AG7 socket. Be sure that the crystal socket pin to which the cathode tank is attached is the one connected to *pin 5* of the 6AG7 tube socket.

6—The screen resistor of the 2E26 tube is made up of two *22K, 2-watt* resistors in parallel. They are connected between the terminal of *S1* and the phenolic terminal strip holding the 500 μμfd. plate circuit bypass condenser.

7—Atop the chassis, the .001 μfd. 1000-volt ceramic condenser coupling the 2E26 plate to the tuning condenser, *C1*, is attached to the plate cap of the tube and the stator arm of *C1*. The plate coil, *L2*, is attached between the stator connections of *C1* and *C2*.

8—The two midget tuned circuits that make up the TV filter are mounted on one stator terminal of *C2*. The parallel tuned trap is made by winding three turns of *#22 d.c.c.* wire around the body of the condenser. The turns of the coil are then varied until the trap is tuned to 57 Mc., with the aid of a grid-dip oscillator. The coil for the series tuned trap is made of eight turns of *#22 d.c.c.* wire wound on the body of a *1-meg., 1-watt* resistor. The turns are spaced so that the coil occupies the full length of the resistor (about ½"). This coil is temporarily placed in parallel with the 33 μμfd. series condenser, and the circuit is adjusted to 57-Mc., with the aid of a grid-dip oscillator. Once this is done, the coil and condenser are reconnected in series across *C2*, as shown in *Figure 30*.

9—All remaining connections and leads may now be completed, and the circuit wiring should be given a final check before power is applied.

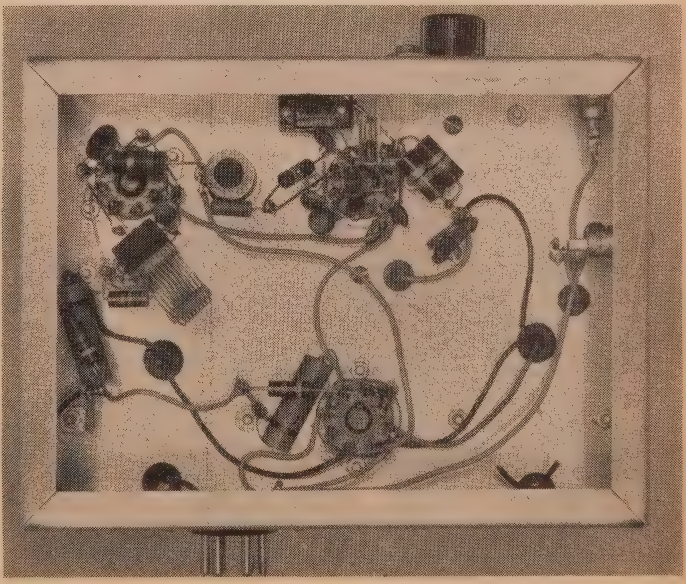


Fig. 31. Under-chassis view of the Simplex-28 The fixed tuned cathode coil of the 6AG7 oscillator stage is visible in the upper left corner of the chassis. The 6V6 modulator socket is at the bottom of the photo, next to the power plug.

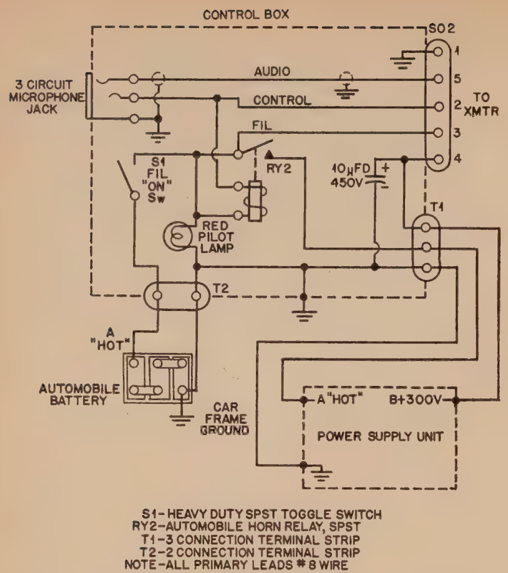


Fig. 32. Control circuit for Simplex-28 transmitter.

Testing the Transmitter

As in the case of any mobile transmitter, it is wise to attach the *Simplex-28* to an a-c operated power supply for preliminary check-out. This will save wear and tear on the automobile battery and ignition system, and makes trouble shooting much simpler.

1—The transmitter is connected to a 300 volt, 150 ma. power supply, and the 6AG7 oscillator tube is placed in its socket. A crystal within the proper range (7125-7425 kc) is placed in the crystal receptacle. Coil *L1* may be tuned to the 10-meter band by means of grid-dip oscillator. When plate power is applied to the 6AG7 tube, the oscillator may be monitored by a nearby receiver tuned to the 7-Mc. fundamental frequency of the crystal.

2—Switch *S1* should be placed in the "tune" position, and a 2E26 tube placed in the amplifier socket. A dc milliammeter should be plugged into *J1*, and the slug of coil *L1* tuned for maximum meter reading. When *S1* is in the "tune" position, only the grid current of the 2E26 will be measured on the meter. When *L1* is tuned to resonance, not more than 4 ma. of grid current should be read on the meter. If it is necessary to reduce the grid current to this value, *L1* may be detuned slightly, or the 8K screen resistor of the 6AG7 tube may be increased in value, dropping the output of the oscillator. The slug of *L1* should tune broadly across the entire 10-meter band.

3—A 10-watt automobile headlamp may be connected across the output terminals of the transmitter to serve as a dummy load. Since the antenna relay will not operate on a.c., it may be wedged closed with a toothpick. *C2* should be set to a maximum capacity, and *S1* should be placed in the "operate" position. The current measured in *J1* will jump to some value between 30 and 80 ma., so it is wise to make sure that the meter inserted in *J1* can measure this value of current without damage. When *C1* is tuned to resonance the current will drop to a value close to 20 ma., depending upon the exact value of the dummy load in use.

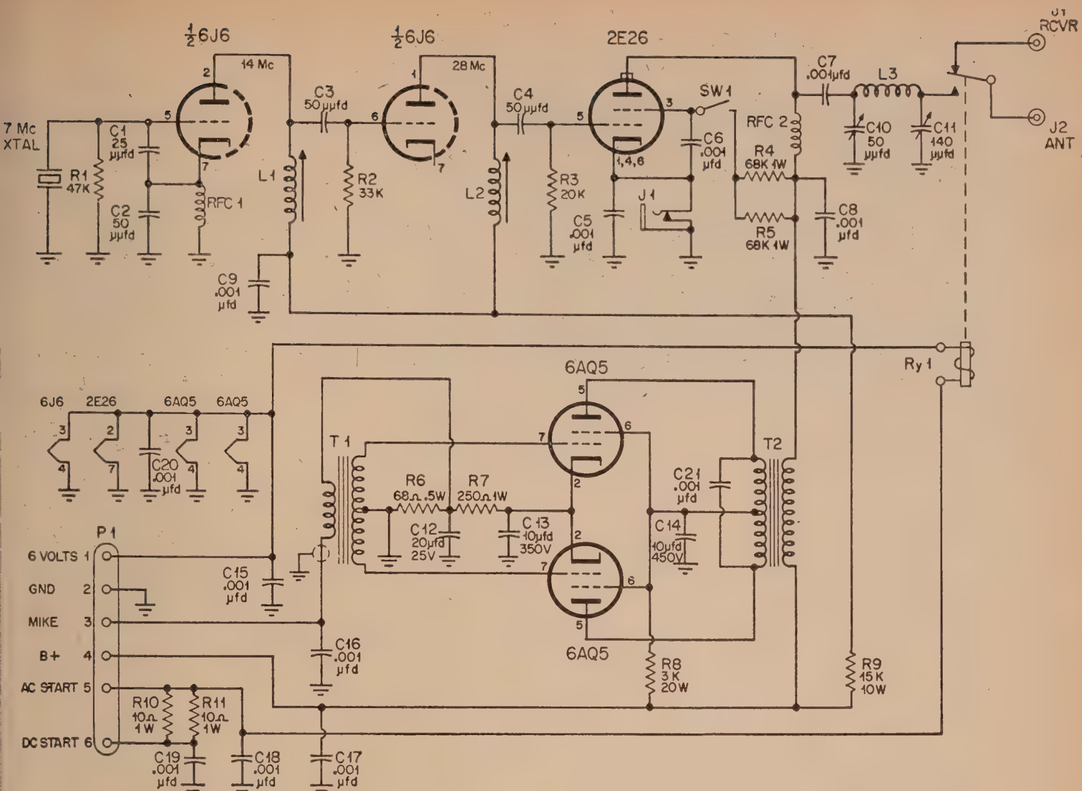
4—The transmitter may now be loaded to full input. As the capacity of *C2* is decreased the loading will increase, and the plate current of the 2E26 will increase. After any change in the setting of *C2, C1* must be retuned for the minimum plate current dip. The plate current of the 2E26 may be loaded to any value between 45 ma., and 75 ma., depending upon the capacity of the power supply.

5—As a parasitic check, the crystal should be removed from its holder while the transmitter is operating. The r-f output of the transmitter should drop to zero, and the plate current of the 2E26 should increase to 90 ma., or more. *Caution: Do this test for seconds, only.* Damage to the 2E26 will result if it is run with no excitation. If the 2E26 plate current does not abruptly increase when the crystal is removed, or if there are signs of r-f in the lamp bulb load, a parasitic is present in the 2E26. In this case, a parasitic choke must be placed in the plate lead of the 2E26, next to the plate cap. This choke may consist of a 50-ohm 1-watt resistor in parallel with a coil made of three turns of #16 wire wound over the body of the resistor.

Cautious souls may place this parasitic trap in the plate circuit of the transmitter when it is built, and eliminate the danger of parasitics. In the transmitter shown in the photographs a trap was originally used, but later removed when it was found that it was not needed. Any radical change in parts layout of the transmitter or large change in lead length may require that the trap be placed in the plate circuit.

Installation in the Car

The control circuit for the *Simplex-28* is shown in *Figure 32*. The power supply should supply 300 volts. If a single vibrator supply delivering this voltage at 100 ma. is used, the 2E26 should be loaded to an indicated current of 50 ma., as measured in *J1*. It may be necessary to parallel *C2* with a 50 μμfd. or 100 μμfd. silver mica condenser *(C3)* to allow the plate current of the 2E26 to drop to this low loading value. If the power supply is capable of output of 150 ma. at 300 volts, the 2E26 stage may be loaded to a current of 75 ma., as indicated in *J1*. The input in the first case is



C1—25 µµfd.
C2, C3, C4—50 µµfd.
C5, C6, C7, C8, C9, C15, C16, C17, C18, C19, C20, C21—0.001 µfd., Erie ceramicon 801-001.
C10—50 µµfd., variable.
C11—140 µµfd., variable.
C12, C13, C14—10 µfd., 450v.; 10 µfd., 350v; 20 µfd., 25v., Sprague TVL-3719.
J1, J2—Jack, ICA #2378.
L1—28 turns #24 enam. National XR-50 form.
L2—13 turns #18 enam. National XR-50 form.
L3—8 turns #18 enam., 1" long, ¾" dia., or B&W 3010.
P1—plug Jones 5308AB and socket P308CCT.
R1—47,00 ohms, 1/3w.
R2—33,000 ohms, 1/3w.
R3—20,000 ohms, 1/3w.
R4, R5—68,000 ohms, 1w.
R6—68 ohms, ½w.
R7—250 ohms, 1w.
R8—3000 ohms, 20w.
R9—15,000 ohms, 10w.
R10, R11—10 ohms, 1w.
RFC1—2.5 mh. choke.
RFC2—choke, Ohmite Z-28.
Ry1—relay, 6-volt a-c coil, d.p.d.t., Advance K1504.
T1—microphone transformer, 1:84 ratio, Peerless K-007X.
T2—Modulation transformer, 10,000-8,0000 ohms, Peerless M-013X.

Fig. 33. Wiring schematic and parts list of the 28-28 phone transmitter.

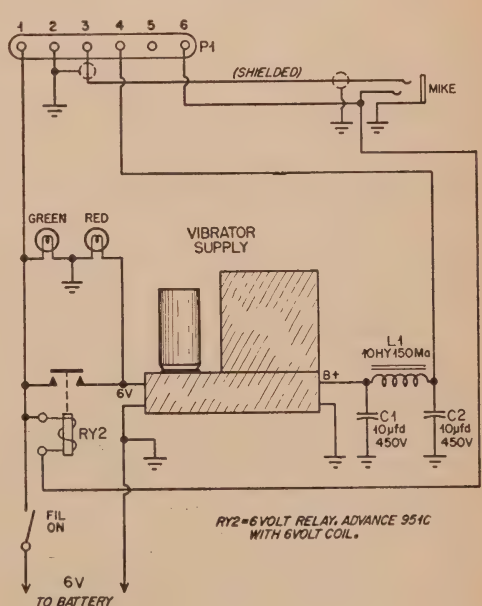


Fig. 34. Control wiring for the 28-28 phone transmitter.

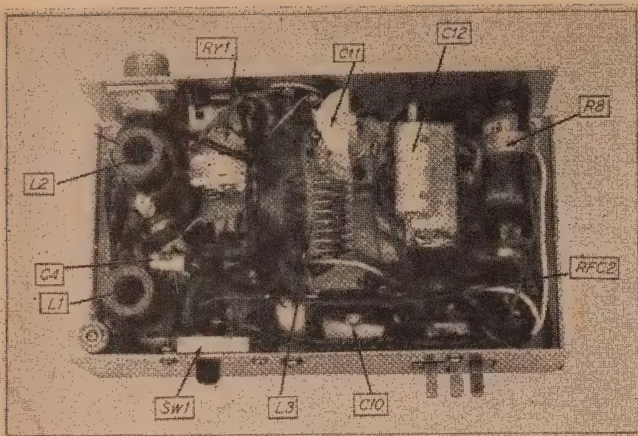


Fig. 35. Underchassis view of the 28-28 transmitter showing the placement of some of the major components.

about 12 watts, and about 21 watts in the second case. Under no circumstances should more than 300 volts be applied to the transmitter.

The transmitter may be coupled to a standard "10-meter whip" by means of a short length of coaxial line of 50 or 72 ohms impedance. The amount of capacity needed at *C2* to correctly load the transmitter will be dependent to some extent on the length of coaxial line between the transmitter and the antenna. If loading difficulties are experienced, the length of the coaxial line should be varied a foot or two until optimum loading is obtained.

the W6MTY Screen-Ten Meter Transmitters

The *28-28* and *28-9* series of ten meter transmitters have proven to be one of the most popular designs carried in *CQ Magazine,* and in the first edition of the *Radio Amateur's Mobile Handbook*. Because of their continued popularity and the increased activity in 10-meter mobile operation, these transmitters are described once again, along with an improved version of the original *28-9* transmitter. All transmitters are the original design of J. Roy Smith, W6WYA.

The 28-28 Transmitter for 10-Meters

This miniature 10-meter phone transmitter is small enough to be placed in the glove compartment of many cars. Complete with tubes, transformers, and send-receive relay it weighs 3½ pounds. It measures 3½" x 6¼" x 4¼", and draws a minimum of plate and filament current. Although designed for 10 meters, the circuit may be modified for other bands.

The transmitter uses three miniature tubes plus a 2E26 beam pentode in a simple, yet complete circuit. It is crystal controlled, and there is no doubling in the class C modulated stage. The transmitter operates on a.c. or d.c., which enables it to be moved about and used as a portable mobile transmitter.

The power requirements are 6.3 volts at 2.15 amperes and any plate voltage between 300 and 500 volts. At 300 volts the transmitter requires 115 milliamperes of plate power. If the car battery is up, this may easily be supplied by a single 100-milliampere, 300-volt vibrator supply. At 500 volts the transmitter requires 150-160 milliamperes. A *Carter Model 450AS* dynamotor will supply the correct operating voltage. A surplus PE-103A may also be used. A *Mallory VP-557* Vibrapack will also work well with this transmitter. At 300 volts, the input will be 20 watts, and the maximum input of 28 watts can be run with a 500-volt supply.

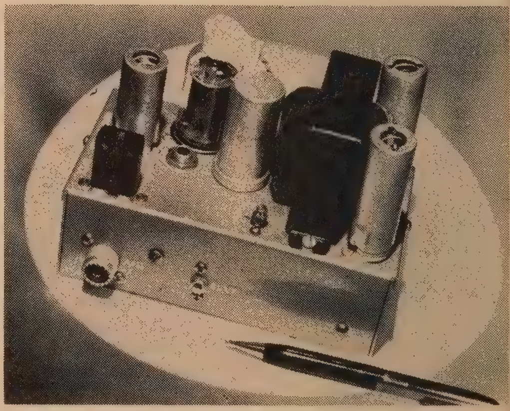


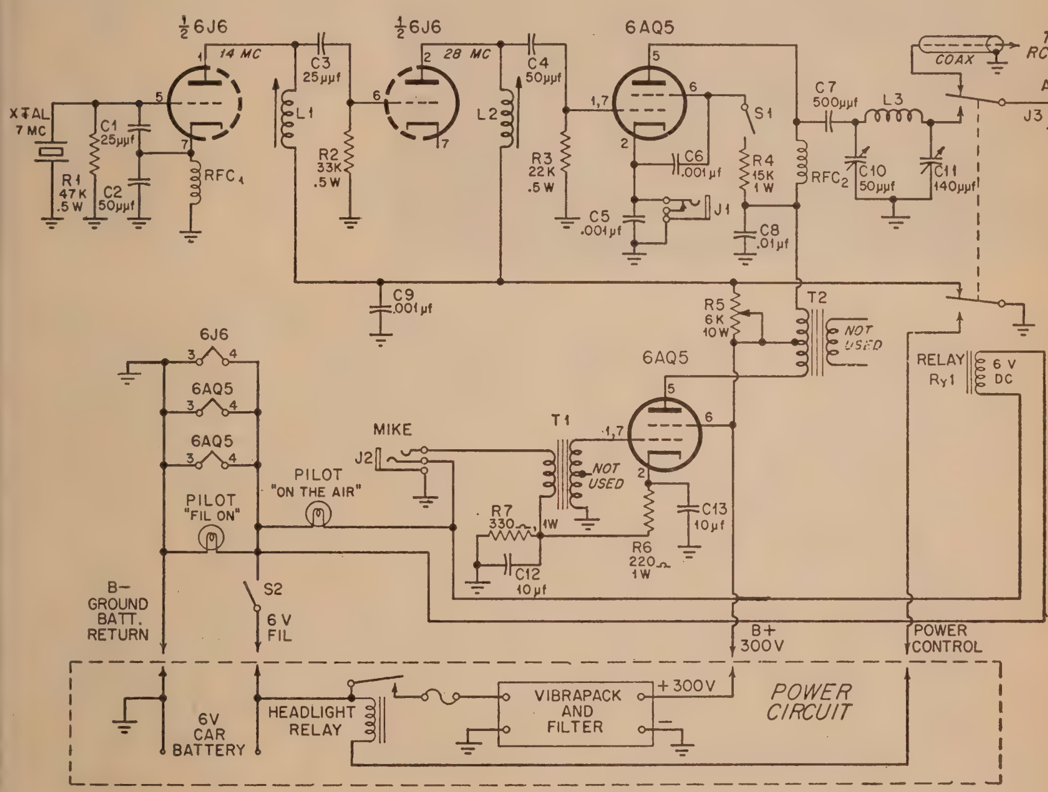
Fig. 36. This view shows the metering jack next to the 2E26 and next to the 6J6 rf driver. The antenna coupling adjusting capacitor C11 is in the center near the modulation transformer.

The Circuit

The r-f driver uses a 6J6 in a frequency quadrupling circuit using a 7-Mc crystal. The first half of the 6J6 is a modified Pierce oscillator, with the plate circuit tuned to 14 Mc. The second half of the 6J6 acts as a doubler to 28 Mc. It is essential that all r-f portions of this circuit (tube socket, coil forms, etc.) be made of low-loss ceramic or mica-filled bakelite. See *Figure 33*.

The slug-tuned inductances resonate with the internal capacities of the tube and the residual circuit capacities to the correct frequencies. This relatively high L/C ratio allows broad band circuits yet still allows relatively high *Q* inductances. With 150 volts on the exciter and a plate current of 14 ma., this driver provides more than enough grid excitation for the 2E26 class C amplifier.

The 2E26 stage has a metering jack in the cathode circuit. This is a shorting type jack so the plate meter may be removed after tune-up. The same jack may be used for indicating either the 2E26 grid current or the total cathode current. When the switch *Sw1* is opened, the d.c. screen voltage is removed and the screen and plate currents are cut off, leaving only the grid current for the meter to read. Closing the switch restores the screen voltage and permits



C1, C3—25 µµfd., ceramic.	C12, C13—10 µfd., 25v., electrolytic.	R1—47,000 ohms, ½w.	Ry1—D.p.d.t. relay, 6v. coil.
C2, C4— 50 µµfd., ceramic.	J1—closed circuit jack.	R2—33,000 ohms, ½w.	S1, S2—S.p.s.t. toggle switches.
C5, C6, C9—0.001 µfd., disc capacitor.	J2—3 circuit jack.	R3—22,000 ohms, ½w.	Chassis—2⅛x3½x6½
C7—500 µµfd., mica.	J3—"ANT" jack.	R4—15,000 ohms, 1w.	T1—Microphone transformer, 1:84 turns ratio (Triad A-5X).
C8—0.01 µfd., disc.	L1—28 turns # 24 enam. on XR-50 form.	R5—6,000-ohm adjustable, 10w.	T2—Replacement output transformer Chitran RO-304.
C10—50 µµfd., midget variable.	L2—13 turns #18 enam. on XR-50 form.	R6—220 ohms, 1w.	
C11—140 µµfd., midget variable.	L3—9 turns #18 enam., 1⅛" long, ¾" dia. from a B&W 3010.	R7—330 ohms, 1w.	
		RFC1—2.5 mh. r-f choke.	
		RFC2—Z28 Ohmite r-f choke.	

Fig. 37. Wiring schematic and parts list of the "28-9" mobile transmitter.

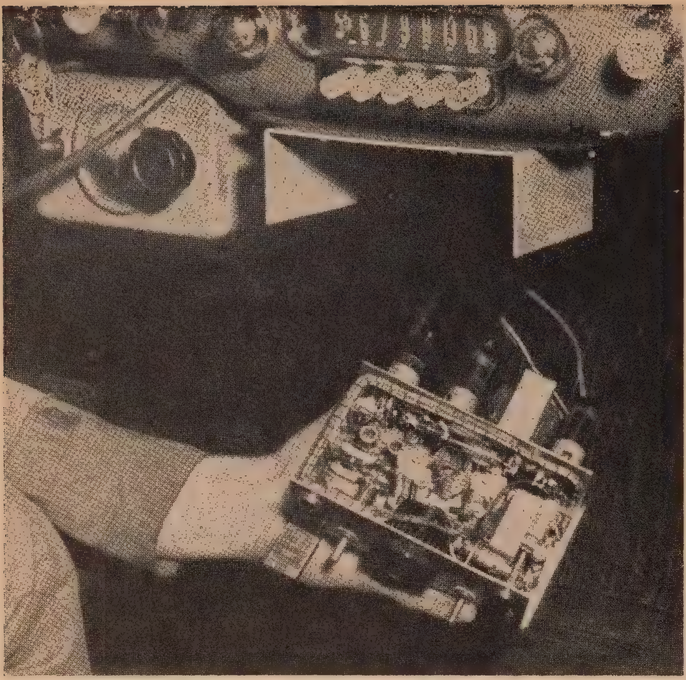


Fig. 38. This under the chassis view shows that the 28-9 may be made into an extremely compact unit. In this model (used by W6DUM) a midget meter has been added in the power lead. The tubes project out the rear apron of the chassis.

plate and screen current to flow. Since the meter is really only needed during tune-up operations it is unnecessary to install it in the transmitter.

The output circuit of the 2E26 is a *pi*-network, designed to work into low impedance loads, such as are presented by the usual mobile whip antenna. It will also match low impedance lines, and random length antennas that might be used for portable work. Final amplifier loading is controlled by *C11*. In some installations it may be necessary to parallel *C11* with an additional fixed capacity of 100 $\mu\mu$fd. to reduce loading to the correct value.

The modulator is a pair of 6AQ5 tubes operating class AB1. This circuit will produce sufficient peak power to fully modulate a class C stage operating at 28 watts input. To make this possible, a microphone transformer with a turns ratio of 1:84 must be used. No additional speech amplification is then necessary. On voice peaks, the 6AQ5 tubes draw grid current which causes the driving voltage to drop. This causes a limiting action which effectively prevents overmodulation while, at the same time, allows a high average level of modulation.

The specified microphone transformer has a resonance of 1400 cycles which is the mid-frequency of the audio band necessary for effective transmission of speech. With the aid of *C8* across the output winding of the modulation transformer the modulator response is within the range of 350 to 3500 cycles, the frequencies of maximum effectivity for speech.

To eliminate the need for a mike battery, the microphone voltage is developed in the cathode circuit of the modulator. A *Western Electric F1*, or a surplus T-17B microphone will work well with this circuit.

The transmitter is controlled by relay, *Ry2*, which is operated by the microphone switch. This circuit may be used to operate another control relay to start a dynamotor, or it may be used to ground the center tap of a power transformer in an a.c. supply. Suggested control circuits are shown in *Fig. 34*.

The control relay, *Ry1*, is a standard 6.3-volt 60-cycle relay. It works well on about 3 volts d.c. In order to drop the voltage for d.c. operation, *R10* and *R11* are wired in parallel and connected to plug *pin 6*, which is grounded by the mike push-to-talk switch. An external transmit switch must be used for a-c operation, as using the microphone control on an a-c circuit will introduce a.c. hum into the audio system.

Construction

The chassis box measures 2⅛″ high, 3½″ deep and 6″ long and may be used. *Figure 35* shows a *Bud AC-431* chassis measuring 2″ high, 4″ deep and 6″ long and may be used. *Figure 35* is an underside view, showing placement of the small parts beneath the chassis. Looking at the top view for a moment: Across one end of the box are the crystal holder, *L2*, the 6J6 socket and *L1*. Between *L2* and the front edge of the box is the antenna coaxial receptacle. *R9* is mounted between *L1* and the corner of the chassis by a long bolt that passes through *R9* and mounts it "end-on" to the chassis. Be sure to put insulating washers on each end of *R9* to prevent the bolt from short-

ng the resistor to the chassis.

The 2E26 socket, *J1*, and the antenna relay ıre in a line parallel to *L1*, *L2* and the 6J6 ocket. *C5* is mounted on *J2*. *Sw1* mounts on ide of the chassis directly above the 2E26 ocket. *C6* is mounted on the 2E26 socket, :onnecting between *pins 3* and *4*. Condensers *:12, C13* and *C14* are combined in one triple ınit, such as the *Sprague TVL-3719*, which nounts in a 1″ diameter hole. The mounting plate should be used with this condenser, as t is next to impossible to solder the condenser o the aluminum chassis. This condenser nounts just about in the middle of the chassis. Condensers *C11* and *C10* are on each side of t, and coil *L3* is suspended below it. *L3* is selfupporting, mounted between the soldering lugs ɔf *C11* and *C10*. A small ½-inch ceramic terninal is mounted to the rear lip of the box ıear *C10*. This terminal supports one end of *:7* and *RFC2*. The plate lead from the 2E26 :omes through an insulated hole in the chassis ınd connects to the stator of *C10* and *RFC2*. Transformer *T2* is mounted above the chassis, ts leads going through two insulated holes to he underneath side. The two 6AQ5 tube sock:ts are mounted at the extreme end of the chassis. *T1* is mounted below the chassis, one end being held by a mounting bolt of *T2*. In the original model shown in the photo, *C12* was not an integral part of the large filter can, but was mounted atop *T2*, the ground end of *C12* being soldered to the frame of *C2*. Resistor *R8* mounts at the extreme end, beneath the 6AQ5 tube sockets. It, like *R9*, mounts "endon" with a long machine bolt. The resistor has two fiber washers at each end for additional insulation.

Wiring

As many parts as possible should be mounted directly on the tube sockets to conserve space. *R1* is mounted across the crystal holder. *C1* is connected between *pins 5* and *7* of the 6J6. *C2* goes between *pins 7* and *4* of the 6J6. *Pin 4* is grounded to the socket bolt. *C3* connects between *pins 2* and *6* of the 6J6. *R2* goes from *pin 6* to *pin 4*. *C9* is connected between the "cold" lug of *L1* and the ground lug on the threaded shank of *L1*. *R3* mounts between *pins 5* and *7* of the 2E26. *Pin 7* is grounded. *C4* goes between the top (hot) end of *L2* and *pin 5* of the 2E26. *C8* goes directly from the "cold" end of *RFC2* to ground. The "cold"

R1, R2—100 K, ½ W.
R3—22 K, 1 W.
R4—15 K, 1 W.
R5—3.3 K, 2 W.
R6—2.20, 1 W.
R7—330, 1 W.
R8—1 M, ½ W.
C1—10 mmf ceramic tubular
C2, C3, C4—50 mmf ceramic tubular or disc
C5, C6, C7—.001 mf ceramic disc
C8—.005 mf ceramic disc
C9—500 mmf midget Mica or ceramic
C10—50 mmf midget variable
C11—140 mmf midget variable
C12, C13—25 mf 25 V. electrolytic
J1—Closed circuit phono jack
J2—Signal Corp. 3 circuit mike jack
J3—Motorola type ant. receptacle

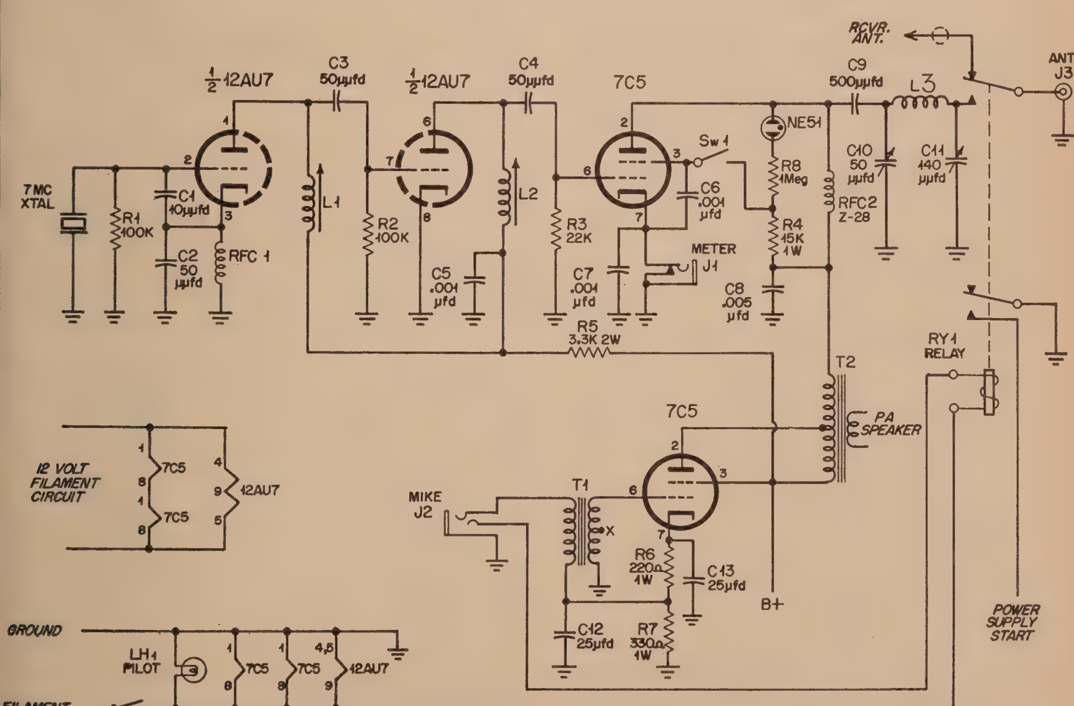


Fig. 39A. Schematic of 1956 version of the 28-9 transmitter.

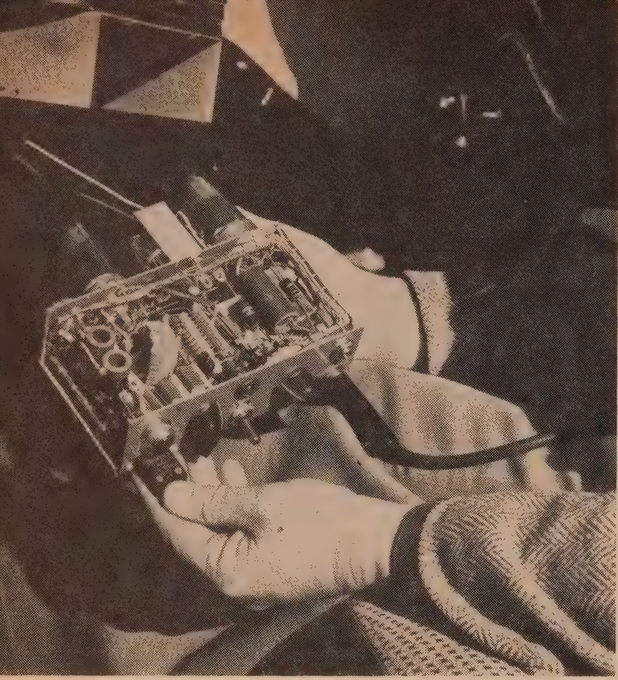


Fig 39B. The 1956 version of the 28-9. This view shows the panel arrangement and the internal layout of parts and wiring. The metering jack is underneath along with the controls for antenna loading and the slug tuned rf doubler controls.

end of *RFC2* should be supported by an insulated terminal, *C8* going directly across this terminal. The remainder of the wiring is not critical as to placement. Condensers *C15, C16* and *C17* mount directly on the power plug and prevent r.f. from entering the cable leads.

Check Out

All wiring should be checked before applying filament voltage to the transmitter. When the tubes are lit, plug in a 7-Mc band crystal. Open *Sw1* to remove screen voltage from the 2E26. Plug a low range (0-15 ma.) milliammeter in *J1*. The center arm of *J1* is "positive." Energizing the relay should indicate grid current of the 2E26 on the meter, if *L1* and *L2* are near resonance. If no grid current is observed, tune a receiver to the fundamental frequency of the crystal oscillator. If the crystal is oscillating, *L1* and *L2* are then adjusted for a grid current of 3-4 ma. on the 2E26. The meter in *J1* should be changed to a 0-100 ma. meter, and *Sw1* is closed, applying screen voltage to the 2E26. *C11* is set at full capacitance. Close the relay and resonate the final amplifier plate circuit with *C10*. Connect an antenna to the transmitter. Loading of the antenna is increased by decreasing capacity of *C11*. Re-dip the final after each change of *C11* by re-resonating *C10*. Continue adjusting *C11* and *C10* until the final is loaded as desired. Maximum loading will be at 70 ma. cathode current.

A field strength meter located several feet from the antenna is very useful in tuning the transmitter for maximum output.

The transmitter generates very little harmonic power. Only very mild interference on channel 2 is noticeable when the transmitter is near a television set of good design. An antenna filter would remove this last trace of interference if placed in the antenna feed line.

the 28-9 Transmitter

The "28-9" is another W6WYA transmitter, designed to work in conjunction with a 300-volt 100-ma. vibrator power supply. It is only 2″ x 3½″ x 6½″ in size and small enough to mount easily under the dash of almost any car. The battery drain of this transmitter, under 100% modulation is less than 9.5 amperes—just about the drain of a good car radio. The circuit is shown in *Fig. 37*.

The r-f driver uses a 6J6 in a regenerative oscillator/doubler circuit that is very effective. The grid of the first half of the 6J6 will work either from a 7-Mc crystal or from 7 Mc. excitation from a VFO. The cathode r-f choke is a standard 2½ mh. 4 pie choke. Condensers *C1* and *C2* provide the r.f. feedback to the oscillator cathode necessary for oscillation. The plate circuit of the oscillator is tuned to 14 Mc. by the self-resonating coil, *L1*. The second half of the 6J6 acts as a regenerative doubler to 28 Mc., regeneration being supplied by the common cathode impedance, *C2*. The plate circuit of the second half of the 6J6 is resonated by *L2* and the associated circuit capacities.

The class C stage uses a single 6AQ5 tube

operating as a straight amplifier. An acceptable substitute for the 6AQ5 would be a loctal based 7C5. The 7C5 is equivalent in characteristics to, and is slightly more rugged than the 6AQ5.

The 6AQ5 is plate and screen modulated by a second 6AQ5. The output circuit of the r-f stage uses a 10-meter plate choke for maximum efficiency and minimum space. The output circuit is a *pi*-network, composed of *C10, C11* and *L3*. The *pi*-network tank does a good job of helping the reduction of harmonics which cause TVI. It will match any antenna in the range of 30 to 500 ohms.

The Audio Circuit

The audio system uses a carbon mike to drive the mike transformer. This transformer is a gem worth all your efforts to obtain. It acts as an effective speech-frequency band pass filter, as its high impedance secondary is in parallel resonance at 1400 cps. (*The Triad Transformer Co.* and the *Peerless Division of Altec Lansing Co.,* both in Los Angeles, Cal., make this transformer.) The center tap on the secondary is not used. The entire secondary with its voltage step-up ratio of 1:84 is connected in the grid circuit of the 6AQ5 audio amplifier. To eliminate the usual mike battery some of the 6AQ5 cathode current is fed through the mike by means of the resistor combination *R6* and *R7*. The mike voltage is 4½ volts with the mike switch closed.

In place of the usual modulation transformer an inexpensive replacement grade push-pull output transformer is used. In this circuit the output or speaker winding is ignored. Almost any such transformer may be used, but it is wise to select one designed for a 14,000-ohm plate-to-plate impedance, capable of carrying 50 ma. of d.c. and whose primary d.c. resistance is less than 300 ohms. Equally important is that it fit the rear of the chassis. Using a transformer designed for 14,000 ohms plate-to-plate the impedance each side of center tap will be sufficient at the low frequency end (300 cps.) for the 6AQ5 to develop full audio power. Since the audio and class C tubes are the same, the "modulation" transformer should have a 1:1 turns ratio, hence the use of ½ of the primary for the audio side and the other half to the class C modulated stage. *A Signal Corps* type 3—circuit mike jack with its smaller opening is used to prevent confusion with the metering jack and to fit the *T-17B* mike plug.

An additional feature of this audio circuit is its use as a public address system for emergency use or to direct the activities of an outdoor Hamfest. Switching the screen switch *S1* off, the class C stage is disabled unloading the modulator. Further, by switching a loud speaker to the previously unused 4-ohm secondary winding of the modulation transformer, 4.5 watts of audio are available for public address use.

The 0.01 μfd. disc ceramic capacitor *C8* in addition to being an r-f bypass capacitor also

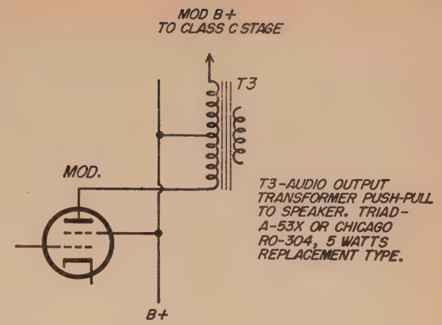


Fig. 40 Alternative modulator circuit when push-pull output transformer is employed in place of special Triad unit

serves to attenuate the higher audio frequencies not required in speech communication. The over-all response of the modulator is within the range of 300 to 3500 cps.

Control Circuits

The control circuit uses a relay actuated by the standard push-to-talk switch in the carbon mike. Since the "28-9" was planned solely for mobile operation in the family car, a d-c relay is specified. The rig may be made to operate on a.c. or d.c. by merely replacing the d-c relay with a 6.3-volt a-c counterpart midget relay, connecting a 4-ohm 5-watt resistor in series. With the series resistor, the a-c relay operates equally well on either a.c. or d.c. The battery current drawn in this arrangement is greater than when using a 6-volt d-c relay.

One set of relay contacts switches the antenna from the receiver to the transmitter. The other set of contacts is used to start the power supply

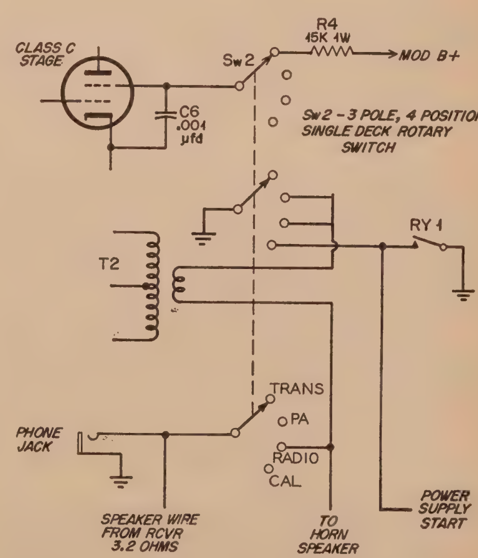
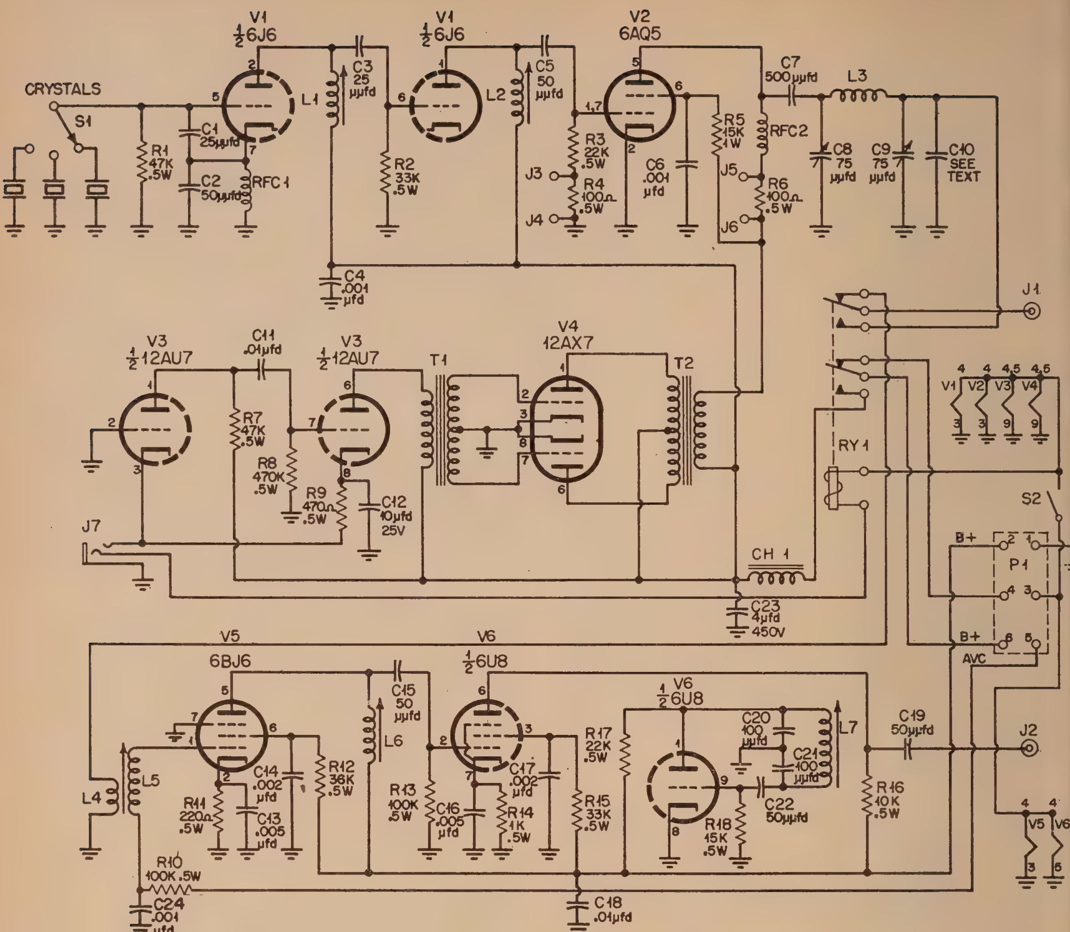


Fig. 41. Control circuit for 1956 version of 28-9 transmitter.



T1—Mike transformer, 1:84 turns ratio (Triad A5X, Peerless KOO7X, Thermador 2L1784)
T2—Modulation transformer (Triad M-4Z)
RY1—D.P.D.T. send-receive relay (Advance MF/2c or equal, with proper voltage coil)
LH1—Lampholder, Dialight Co. #431
Lamp—S-51
RFC1—.5 mh to 2.5 mh
RFC2—Ohmite Z-28 or 1¼" closewound #30 enameled on ¼" dia. form
S1—S.P.S.T. or multiple switch (See text)
S2 — S.P.S.T. filament switch
L1—28T #24 enameled on National XR-50 coil form
L2—13T #20 enameled on National XR50 coil form
L3—9T of B&W 3010 miniductor (#18 1⅛" long, ¾" dia.) or Air Dux #608 T.

Fig. 42. Complete wiring schematic and parts list for the "Combo" Transmitter-Receiver Pg. 138.

and short out the r-f driver plate voltage when the mike switch is released, permitting instantaneous break-in operation. Since the contact current in the midget relay is limited, it is necessary that another relay be used ahead of the vibrator power supply. For this purpose a conventional automobile single headlight relay with its built-in fuse is ideal. The fuse will protect the vibrapack in case of trouble.

Construction

The transmitter is built in a small "Minibox," such as the *Bud CU-2106* or the *L. M. Bender 138*. The box should measure at least 2⅛" x 3" x 5½". The *L. M. Bender* box is slightly larger than these dimensions. All parts are mounted on the main half of the box, as shown in *Fig. 38*. The 6J6 tube is mounted on the back apron to the extreme left. Next to it is the 6AQ5 r-f amplifier. The modulation transformer *T2* is next, and on the extreme right end of the apron is the 6AQ5 modulator.

On the front panel are, from left to right: The crystal holder with the green pilot (Fil. On) above it, the filament switch, the plate meter (if one is used), the screen switch, *S1*, and finally the red pilot (On the air) and the mike jack.

The remaining parts are mounted on the deck of the chassis. Directly in front of the 6J6 socket are mounted *L1* and *L2*. Between these coils and the front panel is the antenna relay, *Ry1*. To the right of *L2* is *C10*, with its slotted shaft projecting out the bottom of the

chassis. *C11* mounts almost directly in front of *T2,* with coil *L3* between *C11* and *C10*. *L3* mounts vertically, and is supported by its leads to *C10* and *C11*. At the right end of the chassis is *T1,* the microphone transformer. *R5,* the wire-wound resistor mounts on end by a long bolt between *T1* and the mike jack. Be sure to put insulating washers on both ends of *R5* to prevent it from shorting to the chassis or mounting bolt. Since chassis space is at a minimum no cable receptacle and plug are used. The power leads come out the back of the chassis through a rubber grommet and are laced with twine to form a cable. A female plug is placed at the end of the cable.

Wiring

It is necessary to use a light grade of plastic insulated wire to prevent the wiring from becoming cumbersome. *Belden 8901* plastic insulated wire will do the job well.

Resistor *R1* should mount across the crystal socket. Mount *C1* between *pins 5* and *7* of the 6J6 socket. Ground *pin 3*. Wire *C2* between *pins 7* and *3*. Wire *R2* between *pins 6* and *3*. *C3* connects between *pins 1* and *6*. *C9* connects to the "cold" end of *L2* and the mounting lug of *L2*. *C4* mounts between the 6J6 socket and the 6AQ5 socket. *R2* connects between *pins 1* and *3* of the 6AQ5 socket, *pin 3* being grounded. *C6* mounts directly between *pins 2* and *6* of the 6AQ5, while *C5* connects between *pins 2* and *3*.

The audio components fit into the space between the 6AQ5 modulator and *T1*.

Tuning Procedure

The coil of relay *Ry1* should be temporarily disconnected and the relay contacts held closed with a matchstick. Apply 6.3 volts a.c. to the filaments of the transmitter. With the screen switch *S1* opened, a meter plugged into *J1* will read the grid current to the 6AQ5 tube. Using a 7-Mc crystal, *L1* and *L2* are adjusted for a

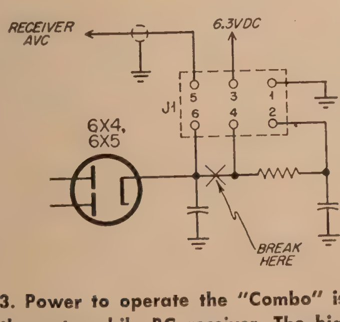


Fig. 43. Power to operate the "Combo" is taken from the automobile BC receiver. The high voltage lead is broken as shown and a filter (choke-capacitance) in the transmitter is substituted.

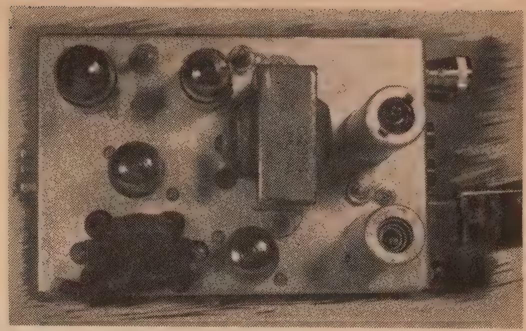


Fig. 44. Top view of "Combo." See text for parts placement.

grid current reading of 3-4 ma. Resistor *R5* may be adjusted to a lower value to increase the output of the 6J6, if necessary. When switch *S1* is closed, the meter will read the total cathode current. With *C1* set at maximum capacity, *C10* is adjusted for a dip in cathode current, indicating resonance. A suitable antenna load should be connected to *J3* and *C11* decreased in capacity until the 6AQ5 cathode current is in the region of 50 ma. *C10* should be resonated each time a change is made in the capacity of *C11*.

In some cases, depending upon the SWR of the antenna system, an additional fixed capacity of 100 $\mu\mu$fd., placed in shunt with *C11* may be necessary to reduce loading to 50 ma. cathode current.

The transmitter should be disconnected from the a.c. operated supply, and the lead to *Ry1* reconnected. The transmitter is now ready for installation in the car.

Antenna Connections

The "28-9" works best with a quarter-wave whip antenna. Since this antenna has a load resistance of only 36 ohms, an impedance matching section is recommended to raise the impedance up to 72 ohms. The matching section consists of a quarter-wave electrical wave length section (67 inches for 10 meters) of 52-ohm coax line with one end connected to the antenna and the other end connected to a 72-ohm coax line of sufficient length to reach the transmitter. Its use affords a better match to the *pi*-network. Also, if the XYL objects to the conspicuous quarter-wave whip, the automobile's regular BC antenna does a good job as the transmitting antenna. A *Motorola* type antenna plug and jack are used as the antenna connection. A short length of coax line brought out through the chassis connects the antenna to the receiving converter.

The 28-9, 1956 Version

From time to time many *28-9* users have asked, "Have there been any improvements in the *28-9* since 1952?"

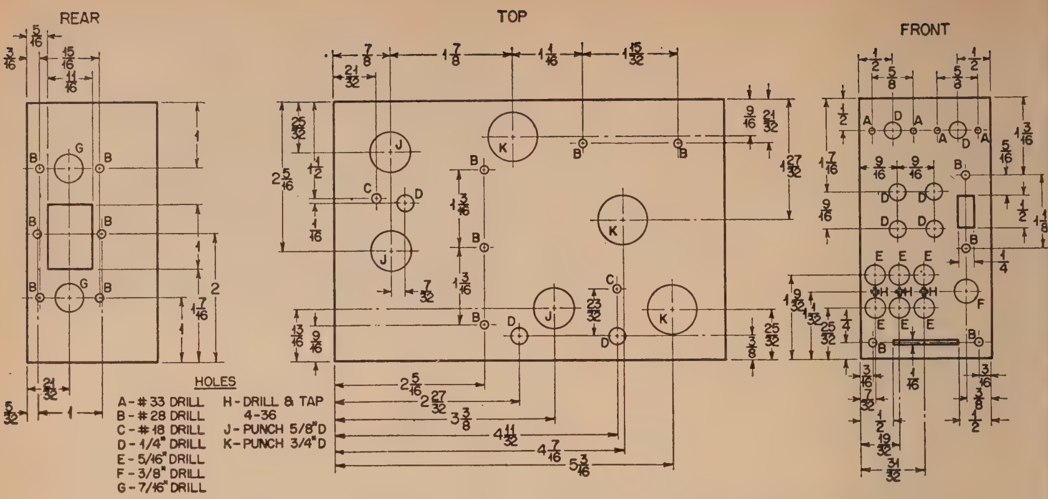


Fig. 45. Principal layout dimensions for this complete transmitter/receiver combination.

Indeed, the *28-9* has progressed through the years. The new version has a change in the r-f driver stage, neon bulb tuning, a modulation and performance indicator, a type-operation control switch and an improved modulation transformer which increases modulation.

This transmitter is easily powered by either a vibrapack or a dynamotor. In most cars the BC receiver's power supply can be switched to the *28-9* and does a fine job with only a fraction of an *S*-unit less output.

Design

The *28-9* uses three tubes; one as an r-f driver, another as a class C amplifier and the third as an audio modulator. The r-f driver now uses a 12AU7 in practically the same circuit as the original 6J6 with the exception of the higher value grid-leak resistors, and higher plate voltage. The use of a 12AU7 simplifies wiring of the filament circuit in transmitters for use in new cars using a 12-volt system. The old 6J6's did not last long when the plate voltage exceeded 150 volts. The class C amplifier uses either a 6AQ5 or a 7C5. By choosing identical tubes of either type for the class C stage and the audio modulator, one spare tube serves as a spare for either circuit. The 7-pin miniature 6AQ5 or the loctal 7C5 are equally effective and they both have essentially the same characteristics. The 7C5 is slightly larger and dissipates the heat better. Also, the 7C5 loctal socket is larger, which makes socket wiring easier.

Both the r-f driver and the class C amplifier operate with grid leak bias. This is the simplest method for bias but does require adequate driving power. The final stage is standard except for the addition of the neon bulb "performance indicator." The pi-network tank circuit is best for antenna matching and attenuation of harmonics.

In the audio modulator circuit, the high step-up microphone transformer eliminates the necessity for both an audio amplifier and a gain control. When the modulator grid is over-driven there is grid limiting in the high impedance transformer secondary, keeping the audio at a constant maximum level. The modulation transformer is a new wrinkle in an old system. It uses a 1:1.16 turns ratio auto-transformer which increases the average modulation more than the usual 100 percent without overmodulating on negative peaks as occasionally happened in the original *28-9*. This transformer also serves as an output transformer for public address use.

The control panel as a part of the chassis is an important design consideration for simplicity and ease of adjustment. All controls requiring adjustment are now on the front panel.

In general, the redesigned *28-9* has retained all its previous advantages and important features and now has some added improvements too.

The R-F Circuit

The r-f driver uses a 12AU7 in a reliable, sure-fire circuit. The first triode operates as a modified Pierce oscillator using a 7 Mc crystal. By means of the resonant circuit, consisting of *L1* plus the circuit and tube capacitance, the first triode doubles in the plate circuit to 14 Mc. The r-f choke in the cathode is not critical. Its inductance may be anything from .5 millihenries to 2.5 millihenries depending upon preference and space available. The second triode performs as a second doubler to 28 Mc. It is seldom necessary to retune the r-f driver when changing frequency *(Fig. 39).*

A 7 Mc VFO may be plugged into the crystal socket, replacing the crystal, but such a VFO must be capable of delivering a small

amount of power—enough power to establish sufficient grid leak bias on the first triode.

The class C modulated stage is simplified to the bare minimum of parts. It uses a pi-network as a tank circuit which does a good job of attenuating harmonics. The neon bulb, *NE51*, uses only 1/25 of a watt of power but is a very effective tuning, modulation and performance indicator. As the pi-network tank circuit is resonated the lamp glows brighter. As the loading is increased the lamp dims. Modulating the signal causes the bulb to glow brighter with upward modulation and dimmer with downward modulation. A change in average unmodulated brilliance also indicates a change somewhere in the entire transmitter, hence it serves as a performance indicator.

The closed circuit meter jack is a "must" item. A meter is needed only during the initial tune-up operation. With a milliammeter plugged into the jack the total cathode current (plate, screen and grid) may be measured. When Switch *S1* is opened the screen and plate current ceases, leaving the meter indicating only the control grid current. When adjustments are complete, the meter plug is removed. Further plate tuning due to frequency changes can be accomplished by tuning for maximum brilliance on the neon bulb.

A hand-constructed frequency-rated plate choke may be used in place of the *Ohmite Z-28* choke, *RFC2*, using closewound number 30 enameled wire over a form ¼ inch diameter by 1¼ inches long.

Audio Circuit

The carbon mike is still the most dependable, effective and inexpensive of microphones. Hence, it is still used in the *28-9* along with the same mike transformer (now this transformer is made by three manufacturers: *Triad*, *Peerless of Altec-Lansing*, and *Thermador*, all located in Los Angeles). This transformer has a 1:84 voltage step-up, eliminating the need for an audio amplifier, and saving precious plate current. Furthermore, it acts as an effective speech-frequency band-pass filter, as its high impedance secondary is in parallel resonance at 1400 cps. This prevents wasting of power in audio frequencies not needed for effective communication. To eliminate the need for a mike battery much of the modulator tube cathode current is fed through the mike at the junction of *R6* and *R7*. Capacitor *C12* is essential to prevent audio oscillation and to retain all mike audio voltage within the transformer primary. A carbon mike needs about 30 to 40 milliamperes current, so nearly all of the cathode current is fed through the mike. *R7* serves to prevent cathode-to-filament breakdown should the mike circuit become opened.

The greatest *28-9* progress has been made in the modulation transformer. A special new transformer has been developed for this transmitter by the *Triad Transformer Company, 4055 Redwood Ave., Venice, California.* Although the idea for this transformer was published years ago, it was seldom used, having taken a backseat to the then new class B modulation. With this transformer it is impossible to overmodulate in the negative direction and theoretically possible for the modulating voltage to reach the 150% modulation level in the positive direction without splatter. This increases the effective audio up to the peak cathode emission of the beam pentodes. It boosts the effective audio power and the results are amazing. Occasionally signal reports are received such as readability *5*, signal strength *zero*.

The r-f bypass capacitor *C8* serves also to bypass higher audio frequencies not needed in speech communication. This helps prevent modulation splatter and unnecessarily wide sidebands. The overall audio response of the transmitter ranges from 300 to 3500 cps.

However, if one prefers, a replacement grade 5 watt push-pull output-to-speaker transformer may be used as the modulation transformer as shown in *Figure 40*. The primary is used as a 1:1 modulation transformer. With this circuit, occasionally it is possible to overmodulate in the negative direction.

A *Signal Corps* 3-circuit mike jack, *J2* is recommended. This preferred jack fits the standard 3-circuit mike plug.

The audio circuit has the additional feature of being capable of being used as a public address system. Switching off the screen switch, *S1*, disables the class C stage and unloads the modulator. By switching a horn-type loud speaker to the speaker winding of the modulation transformer, the 4 to 5 watts of audio can be heard for three blocks. The control circuit of *figure 41* performs these operations with a knob.

Control Circuits

The control circuits consist of a send-receive relay and a three-pole four-position single deck rotary switch connected as shown in *Figure 41*.

Coil Winding Data

MAIN SCHEMATIC

10 Meter Operation

L1—72 t. #28 enam. closewound on ¼" dia. ceramic form, CTC LS6.
L2—21 t. #24 enam. closewound on ⅜" dia. ceramic form, CTC LS5.
L3—8 t. #20 tinned, 1" long, ¾" dia., B&W Miniductor 3010.
L4—3 t. #24 enam. closewound over cold end of L5. Wrap L5 with one layer of Scotch tape before winding L4.
L5—21 t. #24 enam. closewound on ⅜" dia. ceramic form, CTC LS5.
L6—15 t. #24 enam. wound on ⅜" dia. ceramic form, CTC LS5.
L7—14 t. #26 enam. closewound on ¼" dia. ceramic form, CTC LS6.

WAVEMETER

L1—15 t. #20 enam., 15/16" long, ¾" dia. Coil form—Amphenol 24-5H.
L2—2 t. #20, wound at "cold" end of L1.

Main Schematic (Fig. 42)—Wavemeter (Fig. 48)

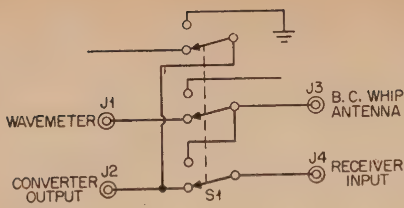


Fig. 47. This switching arrangement keeps peace in the famly by permitting the XYL to "use" the BC receiver. S1 is a 4-pole, 2-position lever action switch (Centralab 1458).

The relay is actuated by the standard push-to-talk switch in the carbon mike. The relay coil should be selected for the voltage of the battery, 6 or 12 v.d.c. A 6.3v. a-c coil can be made to operate on 6 volts either a.c. or d.c. by connecting a 4-ohm 5 watt resistor in series with it.

One set of relay contacts switches the antenna from the receiver to the transmitter during transmission. The other set of contacts is used to start the power supply.

If the receiver power supply is to power the transmitter, this set of contacts can be used to switch the receiver B+ from the receiver to the transmitter. Since the contact current in the midget relay is limited, it is necessary that another relay, such as a headlight relay with its built-in fuse, be placed ahead of the vibrapack or dynamotor.

The transmitter illustrated uses the switch and control circuit of *figure 41*. Starting from left to right the switch positions are (1) Transmit, (2) PA, (3) Rcvr-PA and (4) Calibrate. Position (1) is the normal on-the-air with push-to-talk control. In position (2) the Class C stage is in operation, the loud speaker is connected, and the mike has push-to-talk control for public address work. In position (3) the speaker lead wire from the receiver is tied in to the P.A. speaker. In position (4) the class C stage is disabled by opening the screen circuit, the power supply is automatically turned on. In this position, a meter plugged into the metering jack reads only class C stage grid current.

If the earphone jack as shown in *figure 3* is installed within an inch or so of the mike jack, a *Western Electric* operator's headset may be used when the plugs are modified and a send-receive switch is added.

Power Supply

The *28-9* will operate with power supplies up to 300 volts at 100 milliamperes. A vibrapack is recommended. A PE-101C converted dynamotor makes a suitable power supply furnishing about 290 volts at 100 ma. The automobile-type headlight relay with fuse is essential to connect the vibrapack or dynamotor to the battery.

The power supply contained in the average automobile radio will do a very reasonable job of powering the transmitter. Many of the Washington, D. C. mobile stations have used their receiver power supplies to power *28-9's* to their satisfaction for some time. Should your BC auto receiver have push-pull audio output tubes (more often than not), the internal supply will have adequate power for your *28-9*.

Tuning Procedure

With the screen switch *S1* open or in the "calibrate" position, a meter plugged in the metering jack reads only the grid current. Using a 7 Mc crystal, *L1* and *L2* are adjusted for a maximum grid current of 3 to 4 ma. At this point, change the scale on the meter to read about 100 ma. When switch *S1* is closed or in the "transmit" position and the power supply is turned on, the meter reads the total cathode current. With *C11* set at maximum capacitance, plate tuning condenser *C10* is adjusted for a current dip. Observe that the neon bulb glows brightest at this point of current dip. If the cathode current dips at less than 45 ma. (assuming 300 volt plate supply), the capacitance *C11* may be reduced and *C10* reresonated as before. The process is repeated until proper loading is achieved. Now the meter is unplugged. Once the loading is adjusted, all future tuning may be done by observing the neon bulb glow.

In some installations, an additional fixed capacitor of 100 μμfd or so, placed in shunt with *C11*, may be necessary to reduce loading to 45 ma. cathode current.

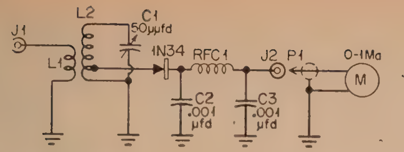
Antenna loading should be kept low enough so that the plate current shows a definite dip at resonance in order to keep the tank circuit at sufficient level of *Q* so as to do its job at attenuating harmonics. At increasingly excessive loading the capacitance adjustment of *C10* at resonance (current dip and maximum neon bulb glow) becomes more displaced from its adjustment for maximum power in the antenna. In every instance, the resonance or current-dip position is the proper adjustment for greatest harmonic attenuation and long life of the class C tube.

When parasitics are observed on a distant receiver (1000 feet distant) they probably are caused by insufficient grid bias to prevent self oscillation since adequate grid bias is controlled by the amount of grid drive.

When downward modulation is experienced, it is probably caused by one of four situations: (1) Insufficient grid drive or excitation, (2) Excessive class C stage loading, (3) Totally insufficient loading or (4) too much voltage drop in the filament circuit; that is, too low filament voltage at the class C tube causing low cathode emission.

Construction Hints

Here are construction hints which have evolved from the building of many of these transmitters. These hints will help you avoid some of the pitfalls of others' past mistakes.



C1—50 μμfd. midget variable (Millen 20050).
C2, C3—0.001 μfd. disc ceramic.
J1—Auto Type antenna jack.
J2—Phono jack.
P1—Phono plug.
RFC1—One or two pies of 2.5 mh four pie choke.
M—0-1 ma.
Chassis—2" x 2" x 1½" Aluminum interlock box.

Fig. 48. This wavemeter circuit has proven to be quite valuable in tuning up and monitoring the "Combo."

Actually these suggestions apply generally to almost any equipment built.

Almost any reasonable arrangement of parts will work successfully providing all r-f leads are kept short. By short, we mean not exceeding one inch in length, preferably ⅜ to ½ inch. The arrangement illustrated in the photograph is very effective. But frankly it is a bit difficult for an inexperienced constructor. It is much better for beginners to start with a larger chassis, yet keeping all r-f leads as short as possible. As you plan the parts layout, orientate all the parts so as to require absolute minimum lead lengths.

Concerning wiring techniques, 28 Mc is practically in the VHF region and VHF wiring techniques should be used. All wire should be color-coded using the standard wiring color code, namely: red for B+, blue for anodes, green for grids, yellow cathodes, orange screen grids, brown filaments, black grounds and ground returns and white for control circuits. Use only stranded hookup wire. Use number 18 size wire in the filament and ground leads in the power lead-in cable. Run the filament wire directly to the battery to avoid the voltage drop existing in the car's connectors, switches and wires. Run all internal ground leads directly to ground to the nearest point on the chassis with very short leads. Even at 28 Mc long leads have sufficient inductive reactance to cause all sorts of feedback paths and possibilities for parasitic oscillations.

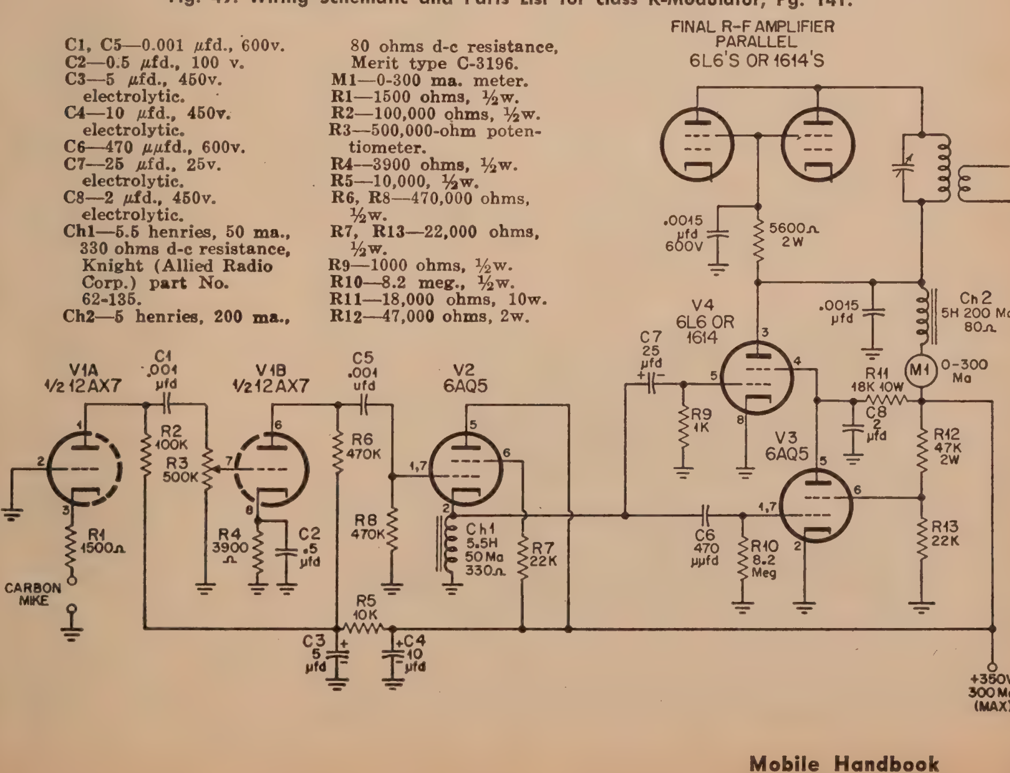
Do not make mechanical joints in the wiring, pigtails and parts leads prior to the application of solder. It is not necessary and it is too difficult to correct wiring mistakes and make changes.

Concerning the slug-tuned coils, the B+ connection should be at the end of the coils nearest the base. This places the iron slug in the "cold" end of the coil and conserves r-f energy. Place the tank coil *L3* so as to be as clear of other parts as possible. Leave adequate room all around the coil for the flow of those invisible lines of magnetic flux which surround the coil. There exists much energy in those magnetic lines of flux and to waste them in adjacent parts generates heat at the expense of your output power.

Place by-pass capacitor *C5* between the B+ end of coil *L2* and the coil's ground lug with leads as short as possible. All other by-pass and

Fig. 49. Wiring Schematic and Parts List for class K-Modulator, Pg. 141.

C1, C5—0.001 μfd., 600v.
C2—0.5 μfd., 100 v.
C3—5 μfd., 450v. electrolytic.
C4—10 μfd., 450v. electrolytic.
C6—470 μμfd., 600v.
C7—25 μfd., 25v. electrolytic.
C8—2 μfd., 450v. electrolytic.
Ch1—5.5 henries, 50 ma., 330 ohms d-c resistance, Knight (Allied Radio Corp.) part No. 62-135.
Ch2—5 henries, 200 ma., 80 ohms d-c resistance, Merit type C-3196.
M1—0-300 ma. meter.
R1—1500 ohms, ½w.
R2—100,000 ohms, ½w.
R3—500,000-ohm potentiometer.
R4—3900 ohms, ½w.
R5—10,000, ½w.
R6, R8—470,000 ohms, ½w.
R7, R13—22,000 ohms, ½w.
R9—1000 ohms, ½w.
R10—8.2 meg., ½w.
R11—18,000 ohms, 10w.
R12—47,000 ohms, 2w.



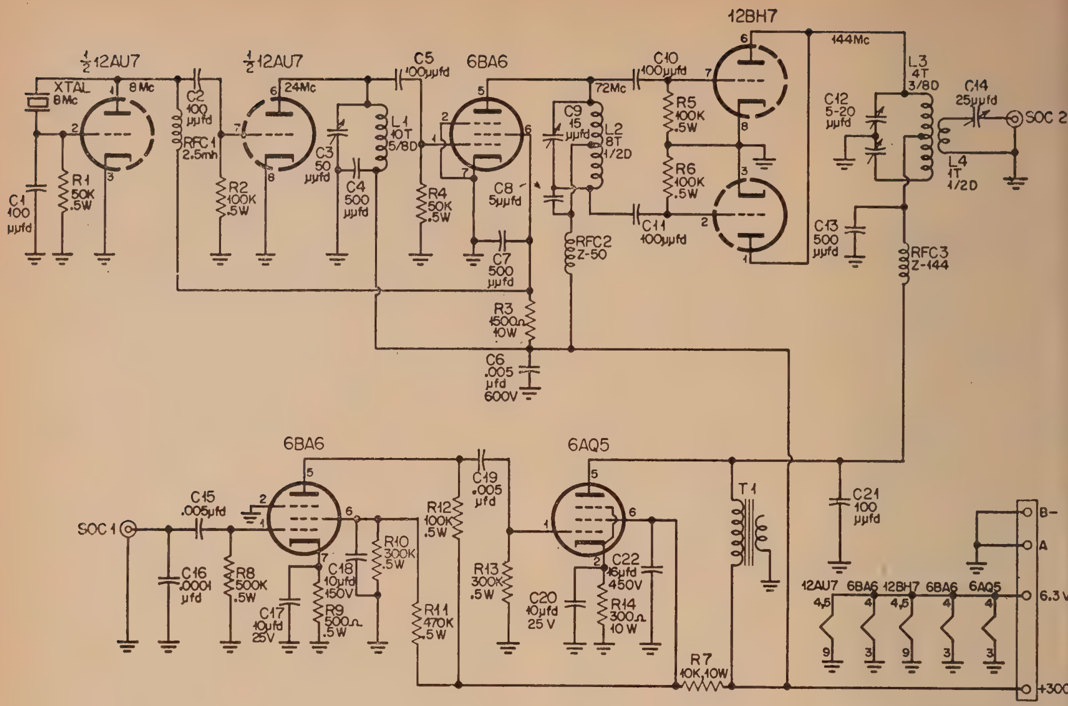


Fig. 50. Wiring Schematic and parts list for 2 Meter mobile transmitter.

C1, C2, C5, C10, C11—100 $\mu\mu$fd. tubular ceramic.
C3—50 $\mu\mu$fd. midget variable, screwdriver adjusted APC.
C4, C6, C13—500 $\mu\mu$fd. 600v. disc ceramics.
C8—5 $\mu\mu$fd. ceramic NPO.
C9—15 $\mu\mu$fd. midget variable, screwdriver adjusted APC.
C12—5-20 $\mu\mu$fd. per section butterfly (Surplus. Similar to E. F. Johnson #25LB15).
C14—25 $\mu\mu$fd. midget variable, screwdriver adjusted APC type.
C16, C21—100 $\mu\mu$fd. ceramic or mica.
C17, C20—10 μfd. 25v. paper electrolytics.
C18—10 μfd. 150v. paper electrolytic.
C22—16 μfd. 450v. paper electrolytic.
R1, R4—50,000 ohms, ½w.
R2, R5, R6, R12—100,000 ohms, ½w.
R3—1500 ohms, 10w.
R7—10,000 ohms, 10w.
R8—500,000 ohms, ½w.
R9—500 ohms, ½w.
R10, R13—300 ohms, ½w.
R11—470,000 ohms, ½w.
R14—300 ohms, 10w.
RFC1—2.5-mh r-f choke.
RFC2—60 T on ¼" rod or Ohmite Z-50
RFC—40 T on ¼" rod or Ohmite Z-144.
T1—Speaker output trans. capable of carrying 75-80 ma. in primary. Ground one side of voice-coil winding. Let other side float.
Xtal—8-Mc. (Exact frequency 1/18 of desired output freq.)
Socl—Microphone connector.
Soc2—Coaxial cable connector.
Power plug—4 prong socket.
Chassis— 5x8x3" aluminum.

coupling capacitors should be wired directly at the tube sockets. Before installing the pi-network variable capacitors, ground the rotor terminal by solder or a snip of wire to the grounded parts of the capacitor. This saves many headaches later in troubleshooting. For r-f by-pass capacitors use only ceramic disc types. Disc capacitors also may be used for coupling but not for the feedback control capacitor *C1*.

The tube sockets should be bottom-mounting types with ground lugs as part of the mounting flange. The r-f tube sockets should be of ceramic or mica-filled bakelite. Tube shields are not necessary. The usual ones hinder the tube's cooling and shorten tube life.

It is recommended that the crystal socket be recessed about ⅜ inch behind the panel with an opening in the front panel to receive the body of the usual FT 243 crystal holder. This takes the mechanical strain off the holder pins, preventing pin breakage when the crystal is accidentally bumped.

The pilot-lamp holder should be the type wherein the bulb is accessible for replacement from the front of the panel by removing the jewel. Pilot lamps have a habit of burning out at the most inopportune time. The neon bulb should be mounted to the front panel in a standard ⅜ inch hole rubber grommet with the bulb extending only about ⅛ inch. Too much of the bulb's protruding affects too much capacitance from the bulb shell to ground causing the bulb to glow excessively. A bulb already glowing too brightly is useless as a performance indicator. Connect the neon bulb by soldering a piece of bus wire to the center connection of the bulb, wiring the other end of the bus wire to the plate connection of the class C final tube socket. The 1 megohm resistor is soldered to the base shell connection of the bulb. These connections also give adequate physical support to the bulb. This neon indicator will seldom need replacing when installed in this manner.

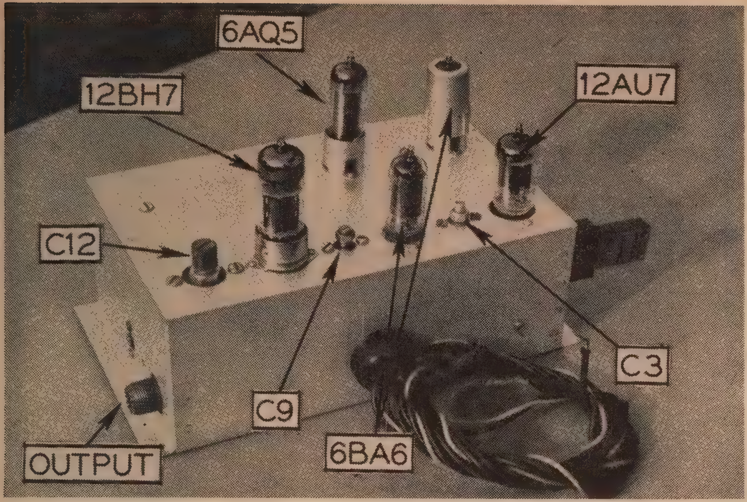


Fig 51. A 12 watt 2 meter mobile phone transmitter.

Conclusions

The *28-9* has several advantages over other transmitters. The filament and power supply drain on the car battery is low. The transmitter and vibrapack consume about 10 amperes from a 6 volt battery including filament and relay currents. The W6WYA *28-9* installation (transmitter and receiver) has operated in continuous contact for as long as six hours on the *Rambler's* one and only battery, and yet the battery started the car with no difficulty. The rig has full high-level modulation with speech bandpass quality audio. All the audio power is concentrated on the speech frequencies necessary in "getting through."

The complete circuit is simple and foolproof. When the wiring is kept short, the usual bugs just don't appear. The control panel is an integral part of the chassis. The transmitter can be built small enough to be placed within easy reach beneath the dash of almost any car without sacrificing leg room. The appearance of the neatest car is not affected in any adverse manner. The neon lamp is a very effective performance evaluator. At a glance one can interpret antenna loading, final tuning, modulation and grid drive. To change frequency it is necessary only to change the crystal and resonate the plate tuning for maximum brilliance of the neon glow lamp. The accessibility of the crystal socket on the front of the chassis makes easy a quick change of crystals.

When the loading is adjusted to where the plate current dip is reasonably pronounced, the set has negligible harmonic radiation. The original transmitter, without additional filtering, causes no TVI when located 50 feet or so from the TV antenna.

The overall circuit is simple and reliable. It contains no parts which are not needed. If good construction techniques are used, there are no areas of probable equipment failure.

Fig. 53. Coil Winding Data for 2 meter transmitter.

L1—10t., ⅝" dia. (part of B&W Miniductor #3007.)
L2—8t., ½" dia. (part of B&W Miniductor #3001, centertapped.)
L3—4t #14 enam., on ⅜" dia. form, ½" long. Centertapped.)
L4—1t., ½" dia. form.

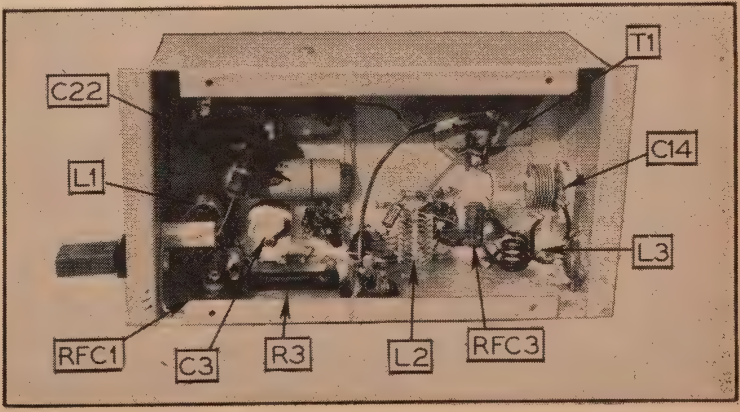


Fig. 52. Bottom view of 2 meter mobile transmitter, showing placement of major components.

the 10-meter "Combo"

It is entirely possible to combine into one package all the necessary components to convert the automobile broadcast receiver into a complete 10-meter station. This package would consist of a low power plate modulated transmitter and a sensitive fixed-tuned converter. The power supply of the broadcast receiver can furnish all the power requirements of the unit, and the BC whip antenna can be used for a transmitting antenna. Such a package is the *"Combo"*.

Circuits

The *"Combo"* is a combination of W6WYA's *"28-9"* transmitter and W2AEF's *"Converterette"*, and the complete schematic is illustrated in *Figure 42*. The transmitter section of the *"Combo"* employs four tubes: a 6J6 double triode as a crystal-oscillator/multiplier which delivers 28-Mc. output from a 7-Mc. crystal, a 6AQ5 p-a stage, a double-triode 12AU7 speech amplifier and a 12AX7 class B modulator. The cathode current of the 12AU7 is used to provide voltage for proper operation of a carbon microphone.

The receiver section of the *"Combo"* employs a 6BJ6 as a fixed tuned r-f amplifier stage, and a 6U8 as a mixer/oscillator. The triode section of the 6U8 is tuned to a frequency of 28.0-Mc. providing a coverage of 28.5-29.6 Mc. on the dial of the automobile receiver.

As previously indicated, the broadcast receiver is called upon to furnish power for both transmitter and converter sections of the *"Combo"*. The supply should be capable of carrying an intermittent load of 300 volts at 100 milliamperes. If the automobile receiver is incapable of this power output, a separate vibrator supply must be used to run the *"Combo"*.

Since most car receivers employ a resistance-capacity filter that is not suitable for transmitting purposes, it is necessary to add a relay to the *"Combo"* to switch the B-plus lead of the receiver so that a choke-capacitance filter is substituted when the transmitter is in use. This relay also silences the receiver when the transmitter is in use. Receiver connections to this relay are shown in *Figure 43*. The relay is designated *Ry-1* in *Figure 42*.

Parts Layout

A top view of the *"Combo"* is shown in *Figure 44*. An aluminum chassis measuring 6″ x 4″ x 2″ is used for the unit. At the front of the chassis are the 6J6 and 6AQ5 tubes that form the r-f section. These tubes mount in holes marked "J" in the layout of *Figure 45*. The two smaller holes between the socket holes (marked C and D) are the mounting holes for *L1* and *L2*. Behind the 6AQ5 tube socket is located *CH-1*, with the 12AX7 modulator tube next to it.

The converter runs along the left rear side of the chassis. The 6U8 tube is placed in socket hole "K", and the 6BJ6 in hole "J". Coils *L6* and *L7* are mounted between these sockets, and *L4-L5* is mounted between the 6BJ6 tube and *CH-1*. To the right of the converter section is the 12AU7 speech amplifier tube, and next to it is the modulation transformer, *T2*.

Three crystal sockets and *S1* are mounted on the front of the chassis, along with transmitter controls *C8* and *C9*. In the center of the front lip of the chassis are *J3, J4, J5* and *J6* and *S2*. Plug *P1* and *J1-J2* are located on the rear lip of the chassis.

In spite of its small size the rig is not difficult to construct and only standard and readily available parts are used. While not essential, a small soldering iron (1/8″ tip) is very handy for getting into some of the tighter spots where the usual 3/8″ tip has difficulty. The relay *(Ry1)* shown in the bottom view is a surplus item that was on hand; the relay specified in the parts list is smaller and should be easier to use.

No attempt will be made to give a "blow-by-blow" description of the assembly and wiring procedure; instead, only a general sequence of events and an explanation of a few points that could cause some trouble. *Figure 45* gives the principal layout dimensions; they are not quite as critical as the figures given would indicate, however. The photograph further illustrates the parts layout and also shows most of the wiring. Though the photograph shows shield bases for the *6BJ6 (V5)* and the *6U8 (V6)*, these are not required, having been installed originally "just in case."

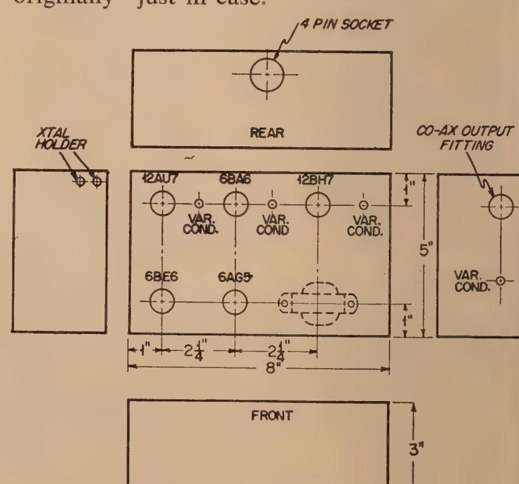


Fig. 54. Suggested chassis layout plan for 2 meter transmitter.

It is suggested that the first step be to wire and test the r-f section, because it is somewhat difficult to work on after all the other parts have been mounted. Switch *S1* is mounted so that the spring is on the inside (facing the socket of *V1*); the lugs on the unused half of the switch are bent so as to allow the switch to fit nearly flush against the chassis walls. If in drilling the holes for *S1* mounting screws, you drill out the chassis spot welds, don't worry. These same two screws will take over the job of holding the chassis together. The leads between the crystal sockets and the switch lugs should be crossed; that is, the bottom lug connects to the top socket, the top lug connects to the bottom socket and the middle lug and middle socket are wired together. By doing this the knob on *S1* will be next to the crystal in use, and will save some confusion when QSY-ing. *RFC-2* is mounted horizontally and parallel to the front chassis wall. One lead is cut to a length of about one inch and is soldered to *pin 5* of the socket of *V3* so that the lead is at right angles to the chassis bottom. The other lead runs horizontally, to *J5*, laying close to *RFC-2*. With one lead attached to *J6*, loop *R5* up and over *RFC-2* to *pin 6* of the *V3* socket. One of the last connections to be made will be the lead from *T2* to *R5*, right at the body of the resistor.

After wiring the r-f section it should be tested for proper operation. Make temporary power connections, plug a 7-Mc. crystal into a crystal socket and set *S1*. Plug a 0-10 ma. meter into the 6AQ5 grid current jacks, *J3* and *J4*. If a mid-band crystal is used, *L1* and *L2* may be tuned, locked in place and forgotten. Grid current to the 6AQ5 should run 3 to 4 ma. The 6AQ5 final amplifier is checked using a 5-watt light bulb as a dummy antenna, and tuning *C8* and *C9* for maximum lamp brilliance. The value of *C10* will vary with different installations, and must be determined experimentally after the rig is in the car.

Following the r-f section, the converter is wired in place. A small aluminum or copper-shield is used to separate *L5* from *L6* and *L8*. The lead between *pin 5* of the *V5* socket and *L6* is run through a small hole drilled in the shield for this purpose. The heater lead to *V5* runs under the shield in the chassis corner. Following the completion of the wiring the converter is aligned and tested.

The first step is to set the local oscillator frequency at 28.0 Mc. by listening for the beat in a receiver tuned to that frequency while tuning *L8*. Two notes of caution: (1) select the stronger of the two signals that will be heard—the other is the image; (2) tune *L8* very slowly as it tunes quite sharply.

Of course, you can set the local oscillator frequency as desired, depending on which portion of the band you want to cover. The frequency of 28.0 Mc. is suggested because the broadcast dial will then read directly in kilocycles above 28 Mc. For example, 28.7 Mc. would be read

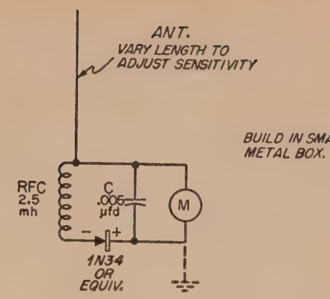


Fig. 55. This untuned r-f indicator is useful in the tuning up of transmitters. The strength of indication will depend on the antenna length and the meter sensitivity.

as 7 (700 kc.) on the dial, 29.2 Mc. would be at 12 (1200 kc.) and so forth. The portion of the 10-meter band covered will be from 28.55 Mc. to 29.6 Mc. on most receivers.

After *L8* has been set, feed the converter output (using shielded lead) into a receiver equipped with an *S*-meter and tuned to the broadcast band. A signal generator of some sort is set to approximately the center of the 10-meter 'phone band and loosely coupled to the converter input. The receiver is tuned near the middle of the band (BC band, that is) for an indication of converter output as read on the *S*-meter. *L5* and *L6* are then peaked for a maximum *S*-meter reading. Lock *L5*, *L6* and *L7* in place and you are through with the converter. See *Figure 46* for coil information.

Installing the Modulator

The speech amplifier and modulator sections are wired in next. *T1* and *T2* are mounted "back-to-back" on either side of the chassis so that one set of mounting holes suffices for both. *T2* is mounted topside with its leads run through grommet-lined holes.

The modulator and speech amplifier should be checked for proper operation before the remainder of the components are installed. Temporarily hook up the r-f and speech sections and note the variation in brilliance of the light bulb dummy antenna as you speak into the microphone.

Relay, *Ry1* can now be mounted and the connections to *L4* and *C9* made at this time. Before mounting *Ry1* disconnect the flexible lead from the bottom lug on the left-hand side of the relay (looking at the top with the relay spring facing you). The relay mounting stud must be cut off and filed down to the level of the nut that secures it. When *Ch1* is installed it is spaced above the chassis by using other *6-32* nuts as spacers. The two leads from *Ch1* are run through grommet-lined holes in the chassis. After *Ch1* is mounted, the power leads to *Ry1*, *T1*, *T2* and *R5* can be permanently connected. As a final step, one end of a heavy (#16 is suggested) enameled copper wire is wrapped around the end of the circular portion of *J1* and soldered. Do not use the small tab

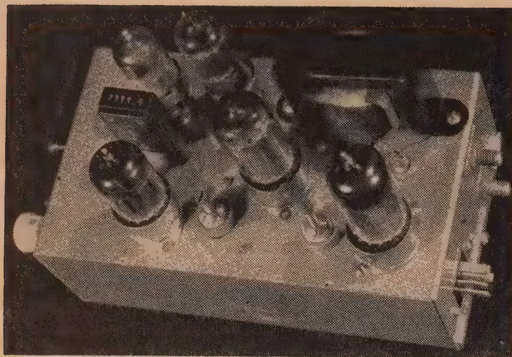


Fig. 56. Midget 2 meter mobile transmitter. A single 6S4 operates as a neutralized class C amplifier, modulated by a 6AQ5. Two exciter tubes are used, a 12AU7 oscillator multiplier and a 5763 doubler. A 12AX7 serves as speech amplifier.

on the end of *J1*, as vibration will eventually cause it to fail. The other end of this heavy lead is brought close to *Ry1* and is connected to the short flexible lead from the relay. This heavy lead should, of course, be bent so as to space it a reasonable distance away from the other components over which it passes.

The transmitter portion will load into the usual BC whip if desired, but the radiated field will be considerably less than if a 10-meter whip is used. The 10-meter whip is much preferred in spite of the attention it attracts.

Switching

In order to keep the XYL's happy, some provision must be made for restoring the broadcast receiver to normal, at least some of the time. This is done the easy way, by switching the receiver input between the converter output and the broadcast whip. This is not only the easy way, but one which will usually provide better reception than if the 10-meter whip is used. The switching is done in a small box that contains only the switch and four antenna jacks (see *Fig. 47*). This method has a disadvantage in that it leaves the converter in operation even when listening to the BC band but obviates the headache that several cables and a few jacks and plugs would produce. This is considered a satisfactory solution to the problem, since the drain is quite small and doesn't hurt the converter. In fact, the transmitter filaments are so seldom turned off that *S2* could easily be omitted.

Installation

Installation is not quite the proper word in this case—you merely "hang it on." For example, the author's rig rides on the floor under the front seat. Only some old popcorn bags had to be removed to make room for it. It is not fastened down in any way, an arrangement that allows it to be removed for servicing, or display to the curious, in a matter of seconds. The power cable, a-v-c lead and converter output cable all run under the front floor mat to a point behind the instrument panel; a socket mounted on the receiver (the only real installation required) takes the power and a-v-c leads while the converter output goes to the switchbox.

The lead to the antenna runs under the rear floor mat and seat, through the trunk, to the antenna. The author's car has a "tunnel" over the drive shaft and by laying the leads in close to the base of this tunnel they go completely unnoticed.

Tune-Up

Tune-up procedure for the transmitter is standard. *L1* and *L2* are tuned for maximum grid current, *C8* is tuned for plate current dip and *C9* is tuned for proper loading, the last two as read on a 0-50 ma. meter in the plate circuit of *V2 (CAUTION: the meter is at B plus)*.

The value of *C10* is determined by setting *C9* at mid-capacitance and placing a large variable condenser in parallel with it. Tune the temporary condenser for proper loading, determine the value to which it has been set (using a capacity bridge, grid-dip oscillator and fixed

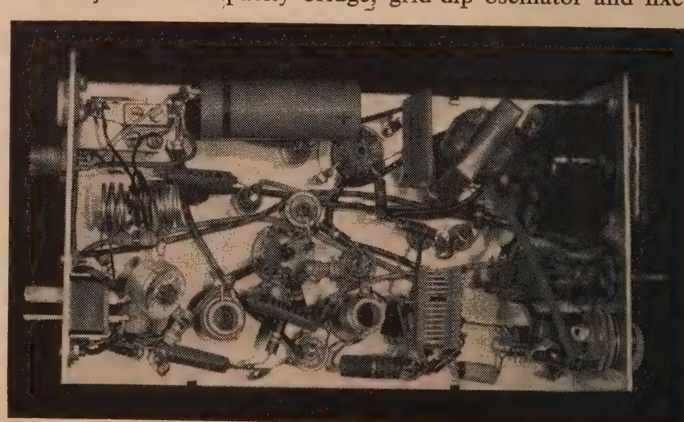


Fig. 57. Under-chassis view of 6S4 transmitter. Major portion of wiring may be done with leads of various components. Point-to-point wiring and use of miniature components permit compact layout without crowding beneath the chassis.

coil, or other means) and then replace it with a small mica condenser of equal value. Subsequent tune-ups are made using *C8* and *C9* only.

The easiest way to tune the transmitter is with the aid of a field strength meter. With the wavemeter *(Figure 48)* tuned to 10 meters, the transmitter can be tuned up by adjusting *C8* and then *C9* to obtain the maximum reading on the indicator of the wavemeter. The meter also affords a means for monitoring the transmitter output. The value of *C10* can be determined more readily if the field strength meter rather than a plate meter is used to determine proper loading.

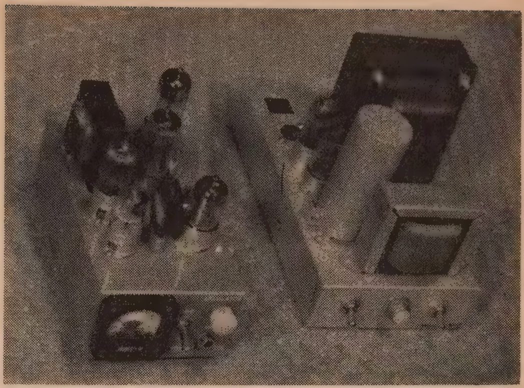


Fig. 58. Complete mobile 2-meter installation is composed of the miniature 6S4 transmitter and a dual voltage vibrator power supply.

the Class K Modulator for Mobile Transmitters

One of the most expensive items in a plate modulator is the modulation transformer. You can avoid this expense by using control-grid, screen-grid, or suppressor-grid modulation, but these methods lose out on the basis of carrier efficiency. Or, if you are ambitious, you can go single sideband.

On the other hand, if you have an ordinary filter choke in the junk box, and if you have the required tubes, resistors, and condensers, you can go class K. Class K modulation is by no means revolutionary; it compares in plate efficiency and physical size to a conventional class AB_1 stage. But it uses no modulation transformer.

Class K Modulation

As described in the October, 1953, issue of *CQ,* the class K modulator is a high-level Heising system employing an audio-controlled modulator-screen clamp tube. A filter choke is used in place of a modulation transformer, and the modulator tube is operated class AB_2. The class K system is *not* screen modulation; it is *not* efficiency modulation; it is *not* low-level modulation. It is high-level *plate* modulation. Briefly, this is how it works:

As shown in the schematic *(Figure 49)* the modulator tube *(V4)* is choke coupled to the plate circuit of the final amplifier. A clamp tube *(V3)* in the modulator screen circuit derives its control voltage from the driver tube *(V2)* output circuit. The modulator tube is virtually zero biased.

The audio is applied simultaneously to the modulator grid and to the grid circuit of clamp tube *V3*. The grid-leak bias developed across *R10* in the clamp-tube grid circuit reduces the average plate current of the clamp tube. The current through *R11* is thus reduced, and the modulator screen voltage rises. Condenser *C8* in the modulator screen circuit prevents the screen voltage from varying at an audio rate but allows it to vary at a syllabic rate. The modulator plate current is therefore a function of the applied audio voltage and is no greater than necessary for a given audio level.

This class K system is similar to the bias-shift system in that the modulator plate dissipation is limited to the value required by the audio level. In the bias-shift system, the modulator plate current is controlled by change of the control-grid bias voltage, while in the class K system, the screen grid is used to control the modulator plate current. The bias-shift system might be applicable to a modulator of this kind, but it requires a fixed-bias supply, a rare commodity in mobile transmitters. The class K system uses no bias supply.

The grid of *V4* is zero biased so that a high modulator plate current can be obtained within a reasonable excursion of the screen voltage. Zero biasing the modulator requires that the driving source supply grid losses on the positive half cycle. In the circuit shown in the schematic *Fig. 49*, a cathode follower is used as a driver to minimize the source impedance offered to the modulator grid. The driver plate current is unfortunately high (about 40 ma.); but if you can think of a more satisfactory method to drive the modulator, more power to you.

The bias developed across 1000-ohm grid resistor *R9* is negligible.

The Transformerless Modulator

The circuit shown in the schematic diagram modulates 50 watts with a single 6L6. A class A 6L6 will normally modulate no more than 20 watts, but used in the class K circuit, the 6L6 delivers over twice its normal rated output; and its plate dissipation is not exceeded. Perhaps this circuit will modulate more than 50 watts, but the transmitter with which it was used would load to only 50 watts.

Although it was designed primarily for use with a mobile transmitter, with a few modifications you can use this modulator just as easily in a fixed-station rig. All that is re-

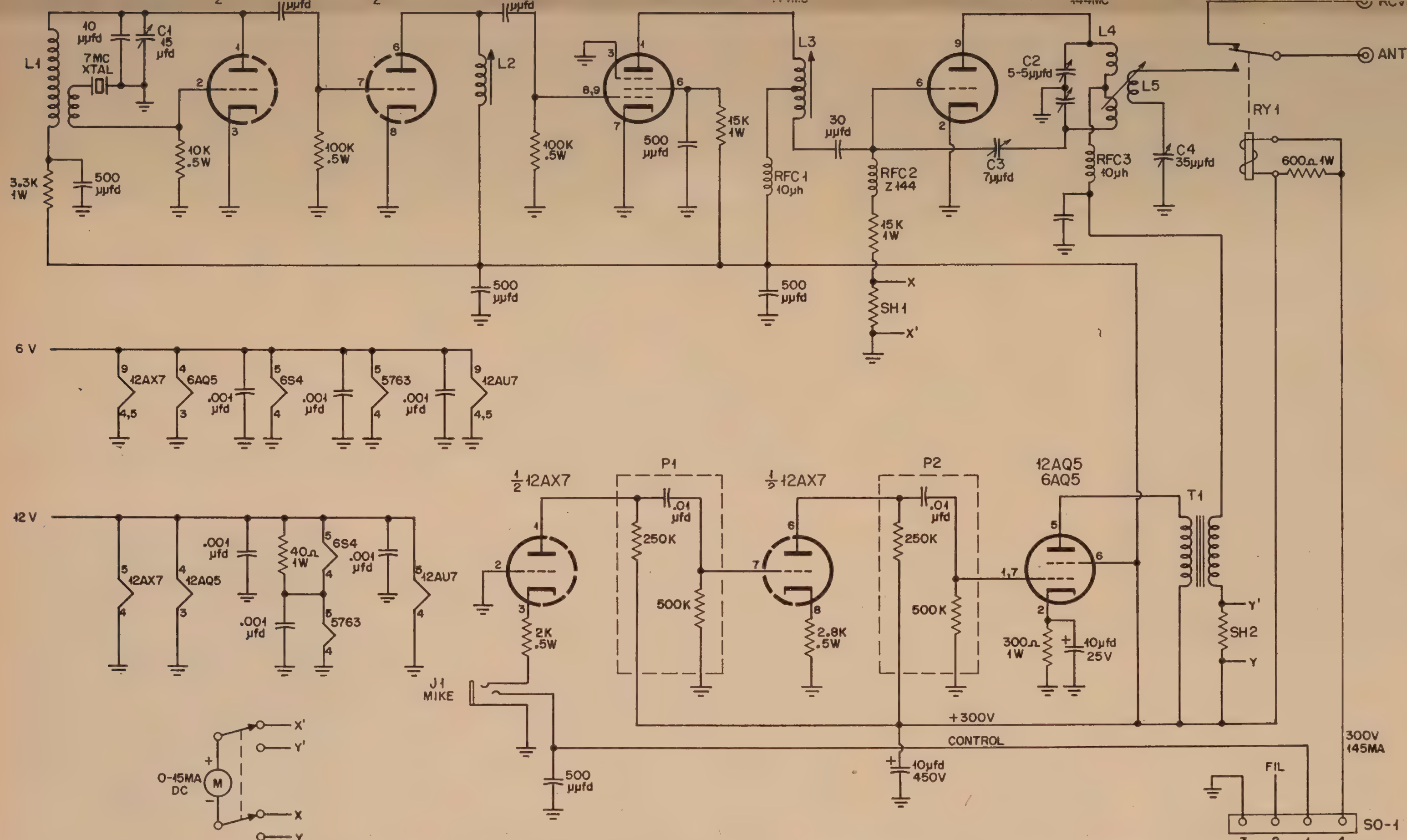


Fig. 59. Schematic, 6S4 2-meter transmitter.

C1—15 uuf. Johnson 15M11
C2 — 5-5 uuf. Johnson 5MB11
C3—7 uuf. ceramic trimmer Centralab 822-EZ
C4—35 uuf ceramic trimmer Centralab 827D

L1—Made from section of B&W 3003 Miniductor. Plate coil is 8 turns, grid coil is 4½ turns. Coils are separated by removing one turn from coil. Coil is ½" diameter and 1" long.

L2—Tunes to 72 Mc with 13 uufd. shunt capacity. CTC-LS5 form (1" long, ⅜" diam) 10 turns #18e. spaced to fill winding area

L3—CTC-LS5 form. 4 turns #18e, spaced to fill winding area.

L4—6 turns #16e., ½" diameter, 1" long, center tapped

L5—2 turns #18e., ½" diameter. Fits between center turns of L4.

P1, P2—Erie 1404-02 ceramic coupling plate

SH1—50 ohms, 1 watt

SH2—"Times ten" multiplier. 0.3 ohms

M—0-10 d.c. milliammeter (3.1 ohms resistance)

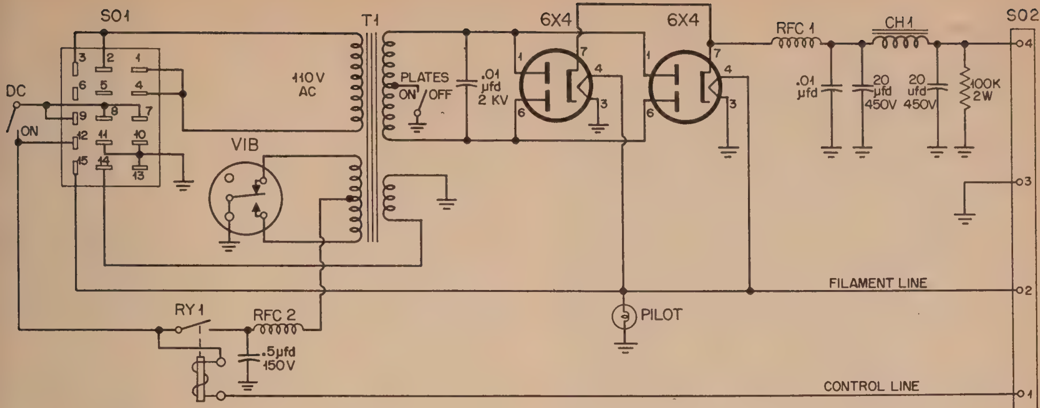
T1—5 watt modulation transformer. 10K pri., 4K sec. Stancor A-3812

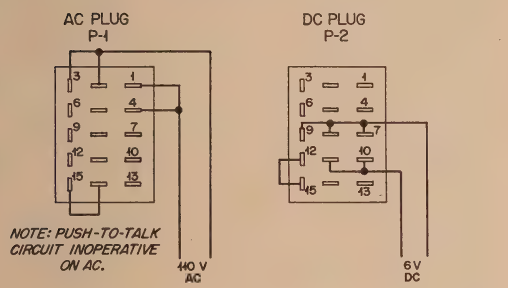
RY1—24 volt d.c. relay from "Command" Transmitter.

RFC1, RFC3 — J. W. Miller 4612 10 microhenry

RFC2—Ohmite 2-144

SO-1—4 prong receptacle





T1—300 volt, 150 ma. vibrator transformer. with 110 volt winding. Merit P-3176.
CH1—12 H at 150 ma. Merit C-3194
VIB—Mallory 294
RY1—Automobile horn relay
SO1—Cinch-Jones S-315 A B
P1, P2—Cinch-Jones P-315CCT
RFC1—2½ mh. National R-100
RFC2—4 microhenry. J. W. Miller 5221

Fig. 60. Schematic, dual primary power supply for 2 meter 6S4 transmitter.

quired for operation with a crystal microphone is that the existing microphone circut be shorted and the crystal microphone be connected from the grid of *V1a* to ground. In this case, a 3.0 megohm resistor should be connected across the microphone circuit. Then if you want better low-frequency response, use a higher capacity for *C1* and *C5*.

The network consisting of *C3, R5,* and *C4* is a dynamotor hash filter for the speech amplifier. If a conventional filter network using a filter choke were used, either in a mobile or fixed-station power supply, the *RC* filter network would probably not be necessary.

The driver tube *(V2)* could have been designed as a conventional grounded-cathode amplifier, transformer coupled to the modulator tube. However, the cost of a driver transformer is greater than the cost of the choke, condenser, and resistor combination. The use of L/C/R coupling between the driver and modulator eliminates the need for even one transformer in this modulator.

The bias for the cathode follower *(V2)* is provided by the voltage drop across *L1*. Therefore, the d-c resistance of *L1* must be close to the value shown. A plate and screen current of about 45 ma. flows through *V2* and *L1*, providing a bias of close to 15 volts.

The clamp tube swings the modulator screen voltage between 30 and 175 volts. The values of *R12* and *R13*, the clamp tube screen voltage divider were chosen to provide an adequate modulator screen voltage swing and at the same time a minimum modulator resting plate current. The modulator plate current swings between 20 ma. and 80-100 ma. The final amplifier plate and screen current is approximately 150 ma. The minimum current indicated by *M1* is therefore about 170 ma., and the maximum is about 240 ma.

Modulation choke *(L2)* should have an inductance of at least 5 henries and a current carrying capacity equal to the final amplifier plate current plus about one-half the modulator plate current. The lower the resistance of this choke, the less power it will consume in needless heat dissipation.

Parallel tubes were used in the final amplifier stage so that a high value of plate current could be drawn with a plate voltage of only 350 volts. Values shown in the amplifier screen and plate circuit are suitable for parallel 6L6's or 807's. The values for other components used in the modulator circuit are not critical.

Oscilloscope measurements indicate that the circuit provides about 90 percent modulation for a power input of 50 watts to the final amplifier stage. Tests conducted on the air indicated the quality was good and that the modulator had the high-frequency response necessary for "cutting through" the QRM.

a Simple 2-Meter Mobile Transmitter

(described by Ray Fulton, K6BP)

This 144-Mc. transmitter was built after I was asked if I could design a really low-drain model with still enough output to be practicable. I said that I could—if I had the time. The whole matter remained in this status until I began hearing things like, "Well, I guess you really can't do it, after all." Thus challenged, I got busy, and the pictures and the wiring diagram *(Fig. 50)* show the finished result.

Power requirements are 125 milliamperes at 300 volts, d.c., or 100 milliamperes at 250 volts plus 6.3 volts at two amperes, a.c. or d.c. These are the total power requirements for both the r.f. and audio sections of the transmitter. At 300 volts, the final amplifier plate current is 40 ma., which equals 12 watts input. Output is six or seven watts, or about double that of the *SCR-522* surplus transmitter with its much greater current requirements. While the *522* will almost burn out a *No.-47,* 6-volt pilot bulb, this transmitter will burn out one bulb and almost burn out two connected in parallel.

Connected to my large corner reflector beam, *S9* reports over distances of 100 miles and more are quite common with this transmitter. As a mobile transmitter, feeding a 19-inch "spike" antenna, many sixty to seventy mile contacts have been made from good locations.

The Circuit

From its initial appearance on the market, I had been attracted to the 12BH7. Its characteristics looked "two meterish," if you know what I mean. So I decided to give it a trial, as a final amplifier, with the results already described. But reverting to the front of the transmitter, the first tube is an old favorite of mine, the 12AU7. One-half of it is used with 8-Mc. crystals as an untuned Pierce oscillator. This circuit was chosen for simplicity and reliability. With good crystals it "starts" every time, and that is important. The oscillator drives the other half of the 12AU7 as a 24-Mc. tripler, which drives a 6BA6 as a second tripler to 72 Mc. This gives us 72-Mc. output using only two tubes and two tuned circuits.

The 6BA6 won out as the second tripler after testing a number of other tubes in this position. It develops sufficient output to drive the 12BH7, without drawing a great deal of plate current. Also, it does not go "flat" with 300 volts on its plate.

Finally, the 72-Mc. tripler drives the 12BH7 as a push-push doubler to 144-Mc. Note that no two stages in the r-f section are on the same frequency. Self-oscillation is, therefore, virtually impossible. You get crystal-controlled output, or no output at all!

Examination of the audio frequency portion of the circuit reveals that a crystal microphone is used instead of the single-button carbon microphone often employed with low power 144-Mc. transmitters. The crystal microphone results in much better speech quality and eliminates the necessity of supplying d-c microphone current, as required with a carbon microphone. This also eliminates a source of hum modulation in mobile transmitters that frequently develops when microphone current is obtained from the automobile battery. Be sure that a ceramic-type crystal microphone that is immune to moisture is used for mobile operation.

A 6BA6 serves as the microphone amplifier and drives a 6AQ5 as a modulator. The output of the 6AQ5 is choke coupled to the 12BH7 modulated stage by means of a replacement-type speaker output transformer, which acts as a Heising modulation choke.

The only "bug" that developed in the transmitter was a trace of audio feedback that showed up when it was first placed in opera-

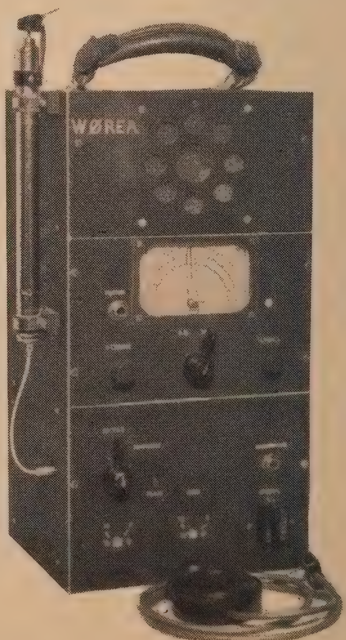


Fig. 61. The 10-6 Packset is a miniature transmitter-receiver designed for operation on the 28 Mc. and 50 Mc. amateur bands. Either 6-volts d.c. or 117-volts a.c. may be used as the primary source.

tion. Shielding the first audio tube and adding two condensers *(C16* and *C21)* eliminated the feedback.

Construction

Top and bottom views of the transmitter are shown in *Figures 51* and *52*. The transmitter is built upon a 5″ x 8″ x 3″ aluminum chassis, with lots of room to spare, though I do not advise crowding it upon a smaller chassis. All components, except tubes and connectors are mounted beneath the chassis.

Layout is straightforward. The r-f tubes and tuned circuits are evenly spaced in a line across the back of the chassis. The crystal socket is mounted vertically on the left end, and the coaxial output connector and the antenna condenser, *C14,* are mounted on the right end. The front half of the chassis is occupied by the audio components. The microphone connector is mounted on the left end in a position to keep the connection between it and the control grid of the 6BA6 *(pin 1)* short. *T1* is mounted under the chassis, to the right of the 6AQ5 socket and in front of the 12BH7 socket. This layout keeps critical components well separated, at the same time, keeping connecting leads short.

Possibly the only component mounting which cannot be determined by inspection of the pictures is *C9,* the 72-Mc. tuning condenser. It is a single-ended condenser tuning a circuit that must supply balanced excitation to the push-pull grids of the 12BH7. Therefore it must be insulated from the chassis and spaced well away from it, to minimize capacity unbalance. Spacing is increased beyond that provided by the normal mounting studs by slipping spacing washers over the mounting screws between the chassis and the studs. This condenser must be adjusted with a non-metallic screwdriver or neutralizing tool.

All tuning condensers are ceramic insulated and with the exception of *C12,* the 12BH7 plate condenser, are screwdriver adjusted APC's. *C12* is a surplus butterfly condenser, similar to the *Johnson 25LB15,* 25-μμfd. per-section butterfly.

Wiring presents no particular problems. This being a v-h-f transmitter, the important thing is to keep all leads in the r-f section to a minimum length. This is best accomplished by sticking fairly close to the specified components and to the arrangement used in the original. It has been duplicated by several W6 amateurs, all with excellent results. Use solid wire for the r-f connections. Most of the smaller components are supported by their leads, with a number of insulated "tie points" employed where necessary to eliminate the possibility of parts flopping around.

Be careful in wiring the 6BA6 stage r-f plate circuit, to minimize capacity unbalance. Connect the 6BA6 plate *(pin 5)* to the stator of *C9,* and connect *L2* directly across the rotor and

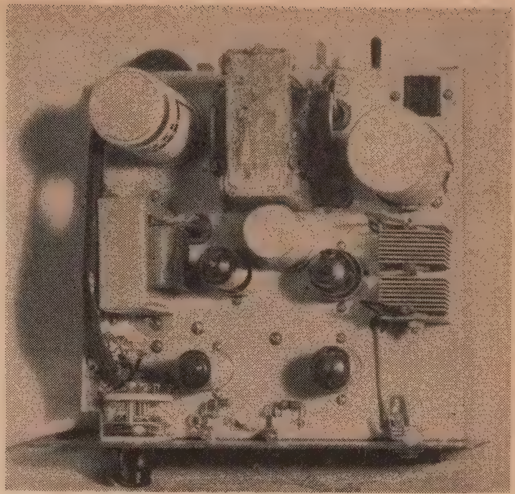


Fig. 62. Top view of the transmitter deck. The r-f components are to the front of the chassis, with the modulator in the center, and the power supply components at the rear. Placement of major parts is shown in Figure 66.

stator terminals of the condenser. Feed the 6BA6 plate voltage into the center of *L2* through *RFC2,* and connect *C8,* a 5-μμfd. ceramic condenser, between the rotor of *C9* and the coil center trap, to compensate for the output capacity of the 6BA6 across the other half of the coil.

Centertap both *L2* and *L3* just as accurately as possible for best results. Consult *Figure 53* for coil information.

Connect the 12BH7 grids *(pins 2* and *7)* to the terminals of *C9* through the 100-μμfd. ceramic condensers, *C10* and *C11*. Then ground each grid terminal through the 100,000-ohm resistors, *R5* and *R6*. Proceeding to the 12BH7 plate circuit, tie the two plates *(pins 1* and *6)* together, and connect another wire from the center of this wire to the nearest stator terminal of *C12*.

Connect *L3* across the stators of *C12*. Feed the 12BH7 plate voltage to the center of the coil through *RFC-3* from *T1* and the plate terminal *(pin 5)* of the 6AQ5, bypassing the tap to the chassis with a 500-μμfd. ceramic condenser *(C13)*. Some transmitters give more output with this condenser omitted; therefore, arrange the wiring so that it can be disconnected, to determine whether it should be left in or removed during preliminary tests.

The antenna coupling coil, *L4,* consists of a single turn around *L3*. One end of it is supported by the center terminal of the coaxial output connector and the other end by the stator of *C14*. The rotor of *C14* is then grounded to a lug under one of the screws fastening the coaxial fitting to the chassis.

In wiring the audio amplifier, only the particular precautions dictated by normal good practice are required. Keep grid and plate cir-

cuit components of the two tubes well separated and all leads short. As mentioned earlier, some audio feedback developed at first, but was cured by the addition of *C16* and *C21* across the input and output circuits. Chassis layout is shown in *Figure 54*.

Tuning the Transmitter

After the transmitter is completed and the wiring checked, it may be tuned. A calibrated grid-dip meter or a wavemeter is invaluable in making certain that the various tuned circuits are actually on the proper frequency.

Another handy tuning aid for use with this and any other transmitter is the untuned field-strength meter diagrammed in *Fig. 55*. It consists of a low-range milliammeter, a crystal diode, an r-f choke, a mica condenser, and a short pick-up antenna. A meter with up to a 5-milliampere movement may be used; however, the more sensitive the meter the better.

Preliminary tuning should be done with reduced plate voltage applied. Start with the oscillator, disconnecting the plate voltage temporarily from the 6BA6 and 12BH7. The oscillator requires no tuning, but it can be checked for proper functioning by a deflection of the milliammeter in the field-strength meter when its pick-up antenna is brought near the plate or grid terminal of the oscillator and by tuning the station receiver to the crystal frequency and hearing the signal being generated.

Next, adjust *C3* for 24-Mc. output from the second section of the 12AU7. If duplicates of the original parts are used, resonance at this frequency should occur with the plates of *C9* just a bit over one-third meshed. Use the field-strength meter to indicate maximum output and the wavemeter or grid-dip meter to insure that the stage is actually tuned to 24 Mc.

Apply plate voltage to the 6BA6 and resonate its tank circuit to 72 Mc. in the same manner. Resonance should occur near minimum capacity of *C9*.

Now, connect two *No. 47*, 6-volt pilot bulbs in parallel to the output connector of the transmitter and apply plate voltage to the 12BH7. Adjust *C12* for maximum output, as indicated by the brightest glow from the bulbs. Then, work back and forth between *C12* and *C14* for a further increase in output. After the transmitter has been tuned up at low plate voltages, the full voltage may be applied and the tuning given a final touch up.

Trying to tune up the transmitter, especially the output stage, by observing plate current dips at resonance is not likely to be too successful, because they are very slight. However, tuning with the aid of a field-strength meter is both simple and effective.

Substituting the transmitting antenna for the light-bulb dummy antenna will probably require re-adjustment of both *C12* and *C14*. Again, the best indication of proper tuning will probably be the field-strength meter reading.

Transmitter Coils (Pack-set)

L10—13 turns #24 on ½-inch polystyrene rod spaced ¾-inch.
L11—6 turns #16 on ½-inch polystyrene rod spaced ¾-inch.
L12—2 turns insulated hook up wire interwound at cold end of L11.
T3—power transformer
Core: 1¼-inch stack, 1-inch center leg laminations #24 gauge dynamo grade iron interleaved 2x2.
130v. secondary wound next to the core 800 turns #30 enameled wire.
110v. primary 660 turns #26 enameled wire
6.3v. secondary wound outside with 42 turns #16 enameled wire—center tapped.

Figure 63.

The purpose of *C14* is to tune out the reactance introduced into the coupling link by the antenna. With some antennas, I have found it to be a great help in getting maximum power into them. With others, it is of little help, although it does afford a convenient means of varying antenna coupling.

There is one precaution to be observed when using the field-strength meter. Do not move around physically while using it. Doing so can cause a large variation in the meter reading, especially when the power to operate the meter is obtained from the power radiated by the transmitting antenna.

Power Supplies

For fixed station use, a 117-volt, a-c supply, capable of delivering 250 to 300 volts d.c., at 100 to 125 milliamperes and 6.3 volts a.c., at two amperes will power the transmitter. About another ampere of filament current and somewhat more plate current will be required, if the 6BK5 is substituted for the 6BA6 frequency multiplier.

For mobile operation, a vibrator-type power supply may be used. At 250 volts, the total current drawn from a six-volt battery by the filaments and the plate supply will be around eight to nine amperes. This assumes a normal vibrator supply efficiency of about seventy per cent. At 300 volts, the battery drain will increase to around twelve amperes.

a Midget 2-Meter Mobile Transmitter

Shown in *Figures 56, 57* and *58* is a small crystal controlled 144-Mc. transmitter designed for either mobile or fixed operation. Employing a universal power supply, this transmitter will operate either from a 6-volt d.c. source, or the usual 115 volt house mains. Power output of the transmitter is in excess of 4 watts.

The Circuit

The schematic of the transmitter is shown in *Figure 59*. Five tubes are employed, three in the r-f section and two in the audio section. A 12AU7 is employed as an overtone oscillator, delivering 36-Mc. output from a 7-Mc. overtone crystal. 7-Mc. crystals of good activity should be employed. In this transmitter, a 7.33-Mc. crystal is normally used, operating on its fifth overtone at 36.6-Mc. The second section of the 12AU7 acts as a frequency doubler from 36-Mc. to 72-Mc. Following the 12AU7, a 5763 pentode operates as a frequency doubler from 72-Mc. to 144-Mc. The final amplifier stage is a 6S4 television sweep triode operating as a neutralized class C amplifier at 144-Mc.

A 12AX7 serves as a two stage speech amplifier, operating from a single button carbon microphone. The microphone is inserted in the cathode circuit, using the plate current of the first half of the 12AX7 for microphone exciting current. If desired, a midget microphone transformer may be used in the input circuit to provide additional audio gain. The speech amplifier drives a single 6AQ5 operating as a transformer coupled class AB modulator stage, which is capable of 100% modulation of the 6S4 class C amplifier.

The Power Supply

A schematic of the dual primary power supply is shown in *Figure 60*. A double winding plate transformer operates either directly from the 115 volt line, or from a 6-volt vibrator, operating from the automobile supply system. Choice of the primary system may be made by inserting the correct power plug into the *Jones*

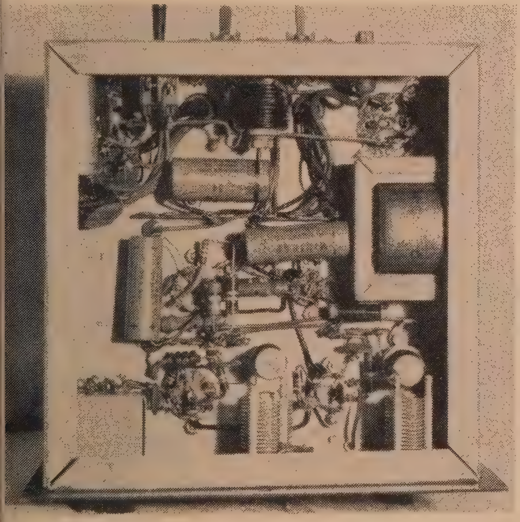


Fig. 64. Bottom view of transmitter chassis. r-f coils of transmitter are wound on Lucite forms and are mounted behind C40 and C44. Placement of major components is shown in Fig. 65.

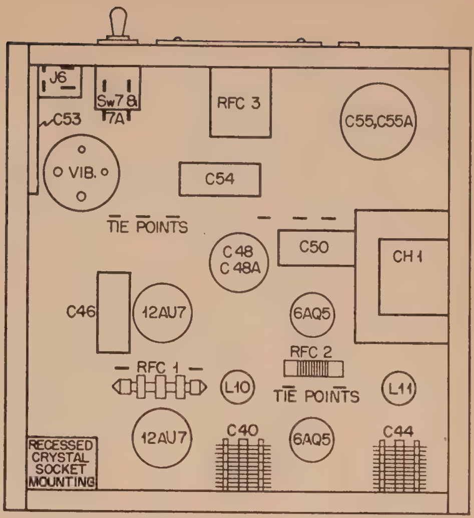


Fig. 65. Transmitter chassis bottom layout.

receptacle mounted on the rear of the power unit. An output of 300 volts at 150 ma. may be obtained from the supply. Connection between the supply and the transmitter is made via a 4-wire cable.

A three circuit microphone jack allows the use of a "push-to-talk" microphone which actuates the d.c. circuit relays in the power unit. For a-c operation, a standby switch is actuated in the center-tap lead of the power transformer. A "D.C. On" switch in the power supply circuit permits the transmitter and supply to be disconnected from the d-c circuits without the necessity of disconnecting the storage battery leads. To allow operation of the antenna relay on either a-c or d-c, a 300 ohm d-c relay coil is used, which is placed in series with the B-plus supply to the r-f section. Thus, when plate current is drawn by the transmitter, the relay is actuated. The relay used in this transmitter is a surplus item salvaged from a defunct SCR-274N "Command" transmitter.

Transmitter Construction

The r.f. and audio sections of the transmitter are built upon a channel-type aluminum box measuring 2″ x 4″ x 6″ in size. The top view placement of parts is shown in *Figure 56*. Across the front of the chassis (to the left) are the 12AU7 crystal oscillator, the 7-Mc. crystal and the 12AX7 speech amplifier. The 6AQ5 modulator is directly behind the speech amplifier socket, and the 5763 doubler tube is behind the crystal socket. The doubler coil, *L2*, is located between the crystal oscillator tube and the 5763. To the right of the 5763 is the doubler coil, *L3*, and the 6S4 output tube. Behind the 6S4 is the shaft of the amplifier plate circuit tuning condenser, *C2*. At the rear of the chassis is the modulation transformer, *T1*.

Mounted on the rear lip of the chassis are

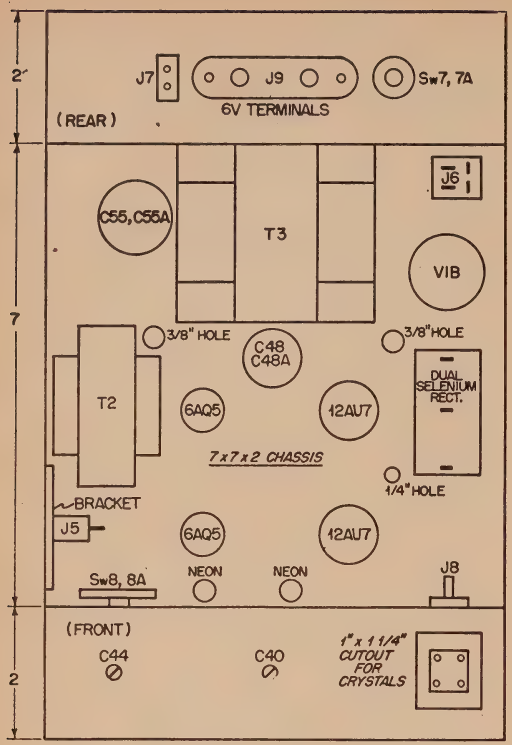


Fig. 66. Transmitter chassis, top layout.

the power plug, the two miniature coaxial jacks for the antenna circuit, and the antenna resonating condenser, *C4*

Located on the front of the transmitter, *Figure 61,* are the plate milliammeter, the meter selector switch, the oscillator tuning control, *C1,* and the microphone jack.

Placement of the major parts beneath the chassis may be seen in *Figure 57*. The double winding oscillator coil, *L1,* is mounted above the oscillator tube socket, held in position by its leads. Between the antenna changeover relay and the power plug on the rear chassis is the p-a tank coil, mounted by its leads to the stator connections of *C2*. The components forming the R/C coupling circuit between the 12AX7 and the 6AQ5 take the form of an *Erie 1404-02* printed circuit plate that is mounted by its leads between the two respective tube sockets. In this particular transmitter, a microphone transformer was employed, and a 6AB4 was used as a single speech amplifier stage instead of the two-stage 12AX7.

The 500 $\mu\mu$fd. bypass condensers indicated in *Figure 59* are base mounting "button" mica units which take up very little chassis space. All wiring is point-to-point, and care should be taken to permit the r-f leads to be as short as is possible.

Transmitter Adjustment

When the wiring has been completed and checked, the 12AU7 oscillator tube and crystal may be inserted in their sockets. Coil *L2* may be tuned to 72-Mc. with the aid of a grid-dip oscillator after the 5763 has been placed in its socket. Once the oscillator is working, a 60 ma. flashlight bulb soldered to a one turn loop of wire may be coupled to the r-f coils to determine maximum output of the various stages.

When the doubler stages are functioning, the 6S4 tube may be placed in its socket, and the B-plus lead from the plate r-f choke to *L4* should be temporarily opened, removing B-plus voltage from the 6S4 tube. The meter switch should be set to read the grid current of the 6S4, and the exciter stages should be tuned so as to produce from 3 to 5 ma. of grid current reading upon the meter. If plate tuning condenser *C2* is now tuned through resonance, the grid current of the 6S4 will show a definite "kick". The ceramic neutralizing condenser *C3* should be then tuned so as to eliminate any reaction upon the grid current when the plate tank circuit is tuned through resonance. After this adjustment is made, the plate wire may again be connected to the center of *L4*. An antenna should be connected to the transmitter, and the coupling between the antenna coil and *L4,* along with the setting of *C4* should be adjusted for a plate current of 35 ma. to the 6S4. The audio tubes may now be placed in their sockets and modulation applied to the transmitter.

As a final neutralizing check, the 5763 tube should be pulled from its socket, and the r-f output of the transmitter should drop to zero. If it does not, *C3* may have to be readjusted slightly. Do not let the 6S4 run any length of time in this fashion, as it is operating without bias, a condition which will damage the tube if it persists for more than a few seconds.

the 10-6 Packset

The FCC regulations governing the operation of amateur radio outline, in effect, that the amateur should use his hobby in the public interest. Most Hams like to do this simply to put their equipment to good use. Ham band communication is now almost taken for granted in times of flood and storm disaster and is coming to be more relied upon for a considerable part of the communications needed in civil defense. The amateur also puts his gear to good use in other less important ways for the benefit of others. At the same time he enjoys himself providing communication at model airplane meets, auto races, parades, golf tournaments, boat races and many civic activities where a roving reporter is helpful to the general cause.

The mobile rig plays a big part in all these activities but quite often the need arises for

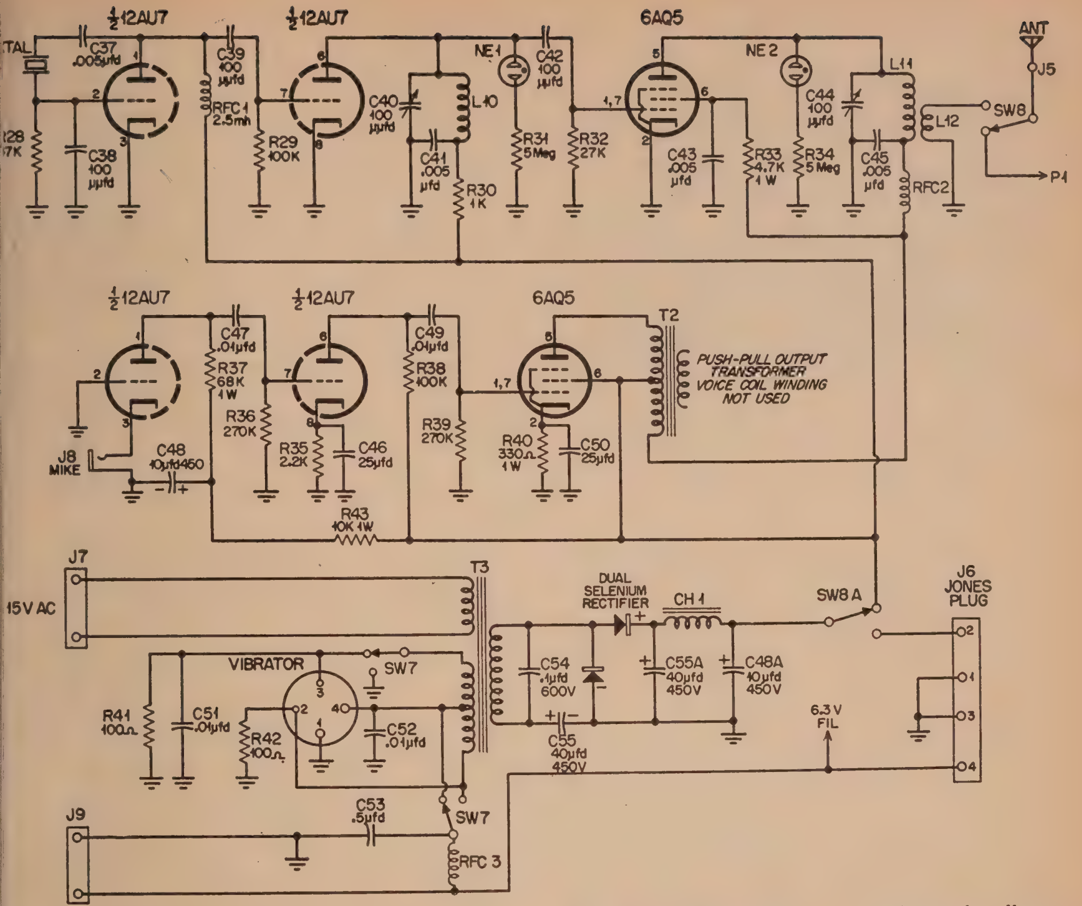


Fig. 67. Wiring schematic and parts list of the transmitter section of the "Packset."

R28—47,000 ohms, ½w.
R29, R38—100,000 ohms, ½w.
R30—1000 ohms, ½w.
R31, R34—5 megohms, ½w.
R32—27,000 ohms, ½w.
R33—4700 ohms, 1w.
R35—2200 ohms, ½w.
R36, R39—270,000 ohms, ½w.
R37—68,000 ohms, 1w.
R40—330 ohms, 1w.
R41, R42—100 ohms, ½w.
R43—10,000 ohms, 1w.
C37, C41, C43, C45—0.005 μfd., disc ceramic.
C38, C39, C42—100 μμfd., ceramic (Erie GP1K).
C40, C44—100 μμfd., APC variable condensers.
C46, C50—25 μfd., 25v. electrolytic.
C47, C49, C51, C52—0.01 μfd., disc ceramic.
C48, C48A—10-10 μfd., 450v. can type electrolytic.
C53—0.5 μfd., 100v. generator type by-pass.
C54—0.1 μfd., 600v. paper.
C55, C55A—40-40 μfd., 450v. can type electrolytic.
T2—8w. push pull output transformer (Stancor A-3823).
T3—Power transformer (see text).
Ch1—85ma. choke not over 2-inches wide (Stancor C-1709).
J5—pin jack Motorola type.
J6—4 prong jones socket #S304AB.
J7—female end of TV accessory cord.
J8—single circuit mike jack.
J9—two lug screw terminal board.
Sw7—8 amp. d.p.d.t. toggle switch.
Sw8, Sw8a—d.p.d.t. wafer switch (Centralab #2003).
P1—Motorola pin type antenna plug.
Ne1, Ne2—#2, 1/25 watt neon bulbs with leads.
RFC1—2.5 mh. RFC.
RFC2—50 turns #28 on ¼-inch form.
RFC3—hash choke, 3 layers #14, 1¼-inch long on ¼-inch form.
Vibrator—Mallory 1501 or equivalent.
Rect.—dual selenium 100 ma., 160v. (Federal 1008A).
Xtal—7Mc. for ten meters, 8Mc. for six meters.

some portable gear that can be easily carried and set up at a remote location. Civil Defense planning calls for emergency powered rigs that can be readily taken wherever they are needed. The "Packset" is one answer for equipment to meet these requirements.

Basic Requirements

The *Packset* shown here incorporates many features found necessary or desirable in this type of gear. The design is based on ideas and suggestions given by a number of amateurs who have had to use emergency equipment in the past. The design incorporates these specifications:

1. The equipment should operate from 6-volt battery or 117 volts a.c.
2. The power supply should be an integral part of the unit.
3. The entire *Packset* should be in one small cabinet.
4. The antenna should mount on the cabinet with provision for feeding a remote antenna as might be required.

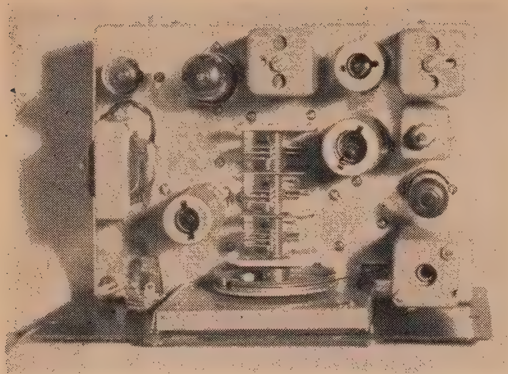


Fig. 68. Top view of receiver section. The simplicity of this excellent receiver is apparent in this view. Placement of major components is shown in the drawing of Figure 73.

5. Operation to be on both ten and six meters.
6. The design should be as simple as possible so anyone could build it.
7. The controls should be as few as possible and uniform so any authorized amateur could operate it without a book of instructions.
8. The cost should be reasonable.

The finished *Packset* is modern and up to date while at the same time not too complicated for the average Ham to build. Even at the current market cost of $90 for parts for the complete unit, the outlay of cash isn't too bad when you consider that while waiting for some emergency to arise, the rig can be used for a mobile job, and even makes a dandy high-frequency station for the shack. With an outside antenna you can work out very well on these frequencies with 6 watts input. The choice of operation on ten and six meters was made after considerable thought on the subject. We have to face existing facts. Ten meters is a popular band, especially for mobile, and communications with them is a must, not only in actual emergencies, but in practice drills. When the ten-meter band is open, however, even local contacts become difficult with DX pounding in on your net frequency, so we have available the six-meter band. In the recent months, activity on this band has increased and it is an exceedingly popular band with the Technician Operators. For an equal amount of power, the actual ground wave coverage on six meters is better than on 10 meters. Construction techniques on the higher band are much the same as for 10 meter gear.

General Circuit Details

The transmitter and power supply are built upon standard 7″x7″x2″ aluminum chassis (*Bud AC-405*), and the complete transmitter-receiver is housed in a steel carrying case, measuring 8″x8″x17″. The lower deck houses the transmitter, the center deck the receiver, and the top deck the built-in loud speaker. The complete unit is illustrated in *Figure 61*.

The transmitter deck (*Figure 62*) contains both the transmitter section and the dual voltage power supply. The tube line-up starts with a 12AU7, one half being a Pierce oscillator while the other half doubles or triples the crystal frequency, as required. A 7 Mc. crystal is used for 10 meter operation, and an 8 Mc. crystal for six meters. The final output stage is a 6AQ5 which doubles at all times. Another 12AU7 is used as a grounded grid microphone amplifier and speech amplifier. The modulator is a 6AQ5.

The coil and condenser combinations in the r-f section were selected to tune the required frequencies without bandswitching. A Pierce crystal oscillator was chosen for the same reason. A dual crystal socket is used, one side being employed for storage of the crystal not in use.

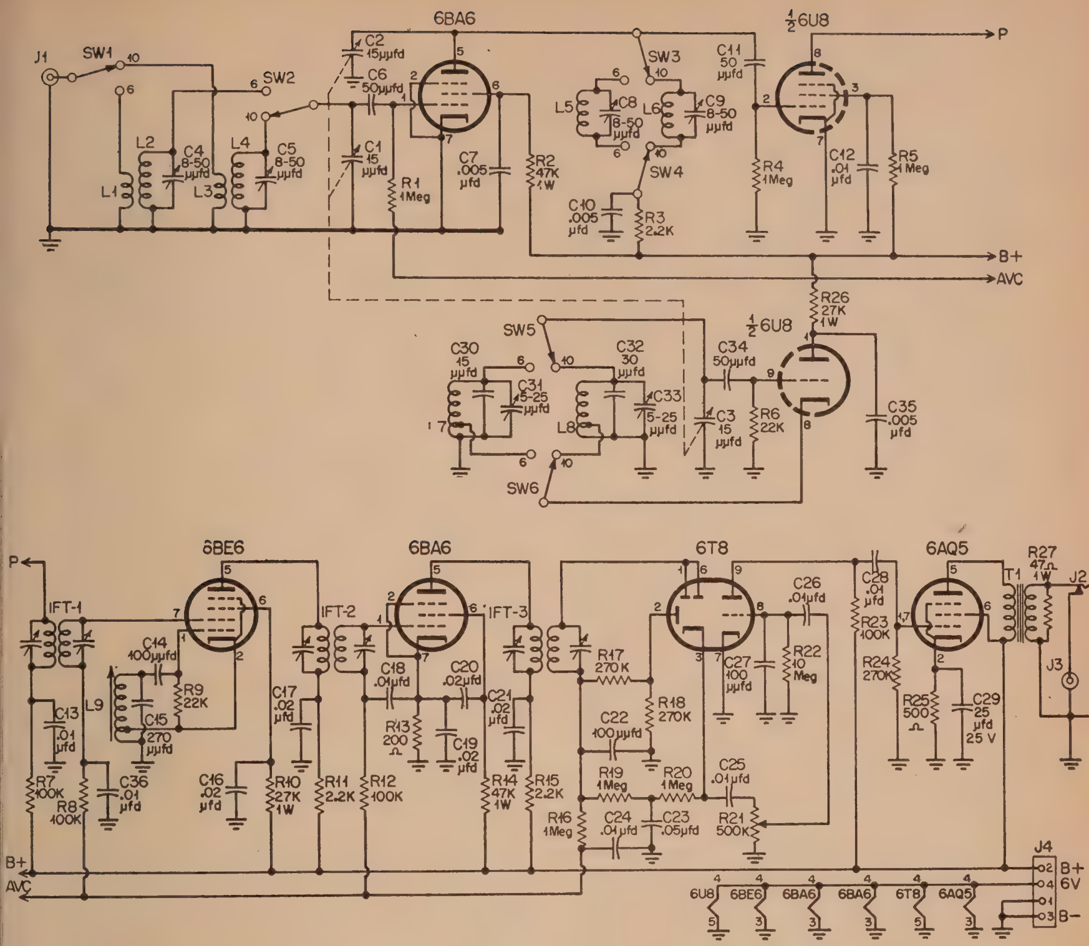
For 10 meter operation, the second half of the 12AU7 r-f tube doubles to 14 Mc., and the 6AQ5 doubles to 28 Mc. (Coil data is given in *Figure 63*).

For six-meter operation, 8-Mc. crystals are used and the 12AU7 now triples to 25-Mc. by retuning the plate condenser, *C40*. The frequency is doubled to six meters in the final. The condenser in the final will be at almost minimum capacity at this frequency and at almost maximum capacity on ten meters. The front panel is marked for condenser settings so band changing can be done quickly. The neon bulbs, (*Ne1* and *Ne2*) viewed through slots in front panel, indicate maximum output settings.

No special precautions are required in building the transmitter and power supply section. The filter choke (*Ch1*) and the two tuning condensers (*C40* and *C44*) are installed after all the wiring has been done. Small brackets are made up to mount the selenium rectifier, the antenna input jack, and the recessed crystal socket.

Grommetted holes are used to bring wiring from the underside of the chassis to the panel-mounted antenna change-over switch (*Sw8*), the output transformer (*T2*) and the selenium rectifier. The a-c line cord is a television accessory with a fitting at either end. The female end is cut off and mounted on the rear of the chassis for the 117-volt input and a regular a-c plug is attached to the remaining length of cord. The male end of the cord fits the jack on the chassis and is removed when battery operation is desired. Separate leads connect to the battery terminals for 6-volt operation. The d.p.d.t. toggle switch (*Sw7*) is thrown into the 6-volt position, which switches the filament winding on the transformer over to act as a primary for the vibrator supply.

A photo of the bottom of the transmitter chassis is shown in *Figure 64*, and parts layout for bottom and top of the chassis are given in *Figures 65* and *66*. Transmitter schematic is



C1, C2, C3—3-15 $\mu\mu$fd., 3 gang variable (All Star Products).
C4, C5, C8, C9—8-50 $\mu\mu$fd., ceramic variable (CRL).
C6, C11—50 $\mu\mu$fd., ceramic (Erie GPK).
C7, C10, C35—0.005 mfd. disc ceramic.
C12, C13, C18, C24, C25. C26, C28, C36—0.01 mfd. disc ceramic.
C14—100 $\mu\mu$fd., silver mica.
C15—270 $\mu\mu$fd., silver mica.
C16, C17, C19, C20, C21—0.02 mfd., disc ceramic (Erie).
C22, C27—100 $\mu\mu$fd., ceramic (Erie GP1K).
C23—0.05 mfd., 200v. paper.
C29—25 mfd., 25v. electrolytic.
C30—15 $\mu\mu$fd., silver mica or CRL "TCZ"
C31, C33—5-25 $\mu\mu$fd., ceramic variable phenolic base (CRL "NPO").
C32—30 $\mu\mu$fd., silver mica or CRL "TCZ".
C34—50 $\mu\mu$fd., silver mica or CRL "TCZ".
R1, R4, R5, R16, R19, R20—1 megohm, ½w.
R2, R14—47,000 ohms, 1w.
R3, R11, R15—2200 ohms, ½w.
R6, R9—22,000 ohms, ½w.
R7, R8, R12, R23—100,000 ohms, ½w.
R10, R26—27,000 ohms, 1w.
R13—200 ohms, ½w.
R22—10 megohms, ½w.
R25—500 ohms, 1w.
R27—47 ohms, 1w.
R21—500,000 ohm midget volume control
IFT-1—1635 kc. i-f. (Miller 12W-1 or surplus).
IFT-2—135 kc. i-f. from surplus marker beacon receiver BC-1206.
T1—output transformer 6AQ5 to voice coil.
J1—antenna jack (Motorola pin type).
J2—closed circuit phone jack.
J3—phono type pin jack.
J4—4 prong Jones socket S304AB.
SW1, 2, 3, 4, 5, 6—2 gang, 2 position, 4 pole wafer switch (CRL #2035).

Fig. 69. Receiver schematic and parts list. The 3-gang variable condenser may be obtained directly from All-Star Products, Defiance, Ohio by mentioning this article and enclosing two dollars ($2.00) with your order.

in *Figure 67*.

The only unorthodox part in the *Packset* is the power transformer. No commercial transformer of this type was readily available so the transformer was wound up according to the specifications in the coil table. The output is about 200 volts under load from either 117-volts a.c. or a 6-volt battery.

Voltage and current measurements are made and recorded for logging before assembling the unit into the cabinet. Final grid current is about 1½ to 2 ma. and the final plate current loaded runs about 30 ma. with the 200-volt plate supply. The entire transmitter draws about 70 ma.

The Receiver Section

A top view of the receiver is shown in *Fig-*

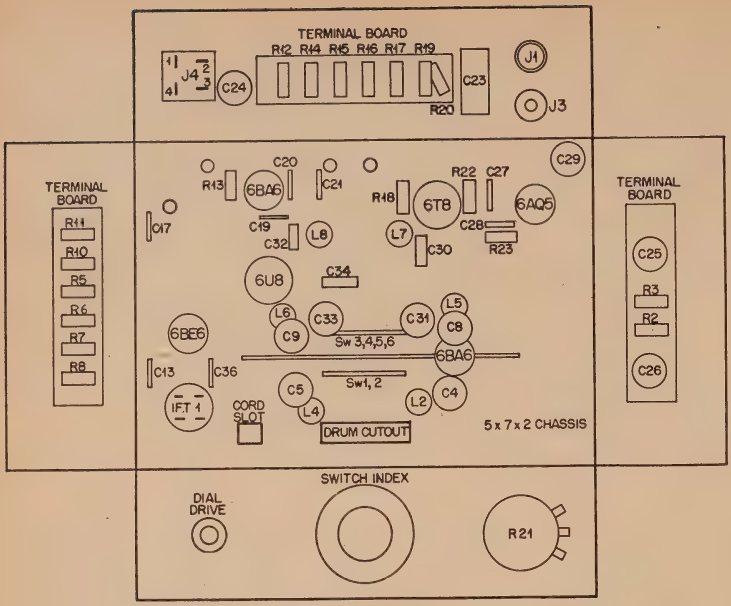


Fig. 70. Receiver chassis, bottom layout diagram.

ure 68, and the schematic is given in *Figure 69.* The receiver is small—built on a 5"x7"x2" aluminum chassis (*Bud AC-402*)—but its performance belies its size. It is a six-tube dual conversion superhet with noise limiter, full a.v.c., adequate speaker output, and band switching for ten and six meters. Fair selectivity was deemed necessary for optimum simultaneous operation of several nets in one band such as planned for RACES and Civil Defense operation. Dual conversion is also a must in a high-frequency receiver to eliminate images and still maintain a degree of selectivity.

The design was made as simple as possible without any special parts so it could be easily constructed. The r-f stage is a 6BA6, the mixer a 6U8, the conversion oscillator and first i-f stage a 6BE6, the second detector, noise limiter and first stage of audio are combined in a single triple diode 6T8, while the audio output tube is a 6AQ5. The speaker plugs into a jack on the rear of the chassis, but headphones can be plugged into the jack on the front panel. Only three controls are on the panel—tuning knob, volume control and bandswitch.

The i-f channels used were chosen because surplus 135-kc. transformers were available in quantity from the "Marker Beacon" receiver, BC-1206. Standard 262 kc. or 175-kc. transformers would be almost as suitable. The frequency of the conversion oscillator was made 1500 kc. so that its harmonics would not fall in any usable part of the ten-meter band. The 18th harmonic falls on 27 Mc., the 19th on 28.5 Mc., while the 20th falls on 30 Mc. Shielding of this oscillator coil *(L9)* and the addition of a small copper shield over the bottom of the 6BE6 tube socket reduces these harmonics to a low value. The harmonics falling in the six meter band are of such a high order that they are much too weak to cause any trouble. Under-chassis parts layout may be seen in *Figure 70,* and the copper shield over the bottom of the 6BE6 socket may be seen in the left side of *Figure 71.*

An i-f of 1635 kc was selected to limit the possibility of strong broadcast stations feeding through the i-f system. Standard 1500-kc i-f transformers can be made to tune to this frequency, while many surplus i-f transformers are available that can be easily modified for the purpose.

The layout and method of construction was planned for ease in assembly. The tuning mechanism is a cord and drum type that gives smooth vernier tuning. The dial proper is a

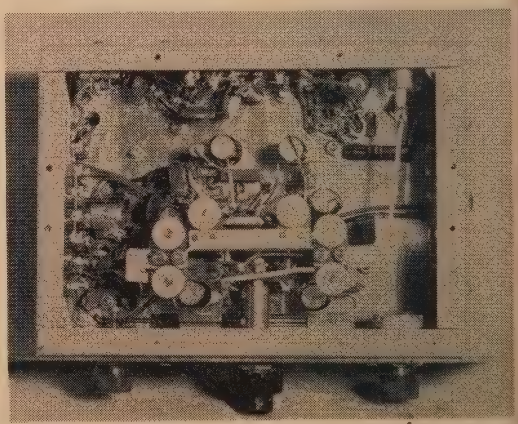


Fig. 71. Bottom view of receiver section showing placement of the major components may be seen in the layout diagram of Figure 70.

Coil Winding Data (Pack-set)

Receiver section

Six meters:

L1—3 turns #30 at bottom of L2.
L2—4 turns #22 on ⅜-inch polystyrene rod spaced ¾-inch.
L5—3½ turns #22 on ⅜-inch polystyrene rod spaced ¾-inch.
L7—3½ turns #22 on ⅜-inch polystyrene rod spaced ¾-inch tapped 1 turn from cold end.

Ten meters:

L3—4 turns #30 at bottom of L4.
L4—9 turns #22 on ⅜-inch polystyrene rod spaced ¾-inch.
L6—same as L4.
L8—9 turns #22 on ⅜-inch polystyrene rod spaced ¾-inch tapped 3 turns from cold end.

Figure 72.

recessed piece of white cardboard behind a Lucite window in the panel, the pointer being attached directly to the condenser shaft. The dial is thus protected from being damaged or the pointer being bent or torn off when carrying the *Packset*.

Most of the resistors are mounted on terminal strips and preassembled before being put in place as units near their location in the circuit. The bandswitch and the ceramic trimmer condensers are mounted on a small aluminum partition, which also acts as a shield between the grid and plate sections of the 6BA6 r-f stage. This assembly is installed last, after all major parts have been mounted and wired, thus leaving plenty of working space. The by-pass condensers are all ceramic types and are mounted right at the tube sockets. Before the r-f coils are put in place, the i-f system can be checked and tuned. The last step is installing the r-f coils and checking the tracking, and, finally, calibrating the dial. Complete coil data is given in *Figure 72*.

The front panel from the cabinet was cut into three sections and two of them used as panels for the transmitter and receiver. The top section is drilled with several large holes and the speaker is mounted behind it, fastened permanently to the cabinet. Two shelves of sheet aluminum were bolted into the cabinet dividing it into compartments for the two separate units that make up the *Packset*. The rear panel of the cabinet is also cut off at the top one third. It is hinged back together again to make a door to the top compartment which is used for the storage of accessories such as extra cables, headphones, mike, and maybe a screwdriver or two. The rear of the speaker is covered with copper screen to prevent damage to the cone.

A short cable is used to connect the two units in the cabinet and the antenna plugs into the transmitter section through a hole in the side of the cabinet. The antenna is a fully collapsible type that is mounted on the side of the cabinet and extends to 52 inches when in use. This length is about right for six-meter operation. Although it is too short for ten meters, it will load up and the radiation is adequate for local work over several miles.

Conclusion

Several of these *Packsets* have been built up during the past year and used in a variety of activities with excellent results. The acid test was given during several hours of continuous operation in 90 degree temperature supplying communications for a golf tournament with no equipment failure. A *Packset* makes an ideal hidden transmitter for hunts and can be taken to almost any unlikely location even if you do have to take a battery along. The total battery drain is less than ten amperes and a storage battery lasts a good many hours. Another use is talking back to a fixed station when running down some TVI. Although no special pains were taken to make these units TVI-proof, they have been operated right next to TV sets with no outstanding interference. With an outside antenna they make ideal stations for local rag chewing over considerable distance, and when either six or ten meters are open you are all set to go. A table of voltage measurements in the receiver is given in *Figure 74*.

a Six Band VFO Mobile Transmitter

This rig was built small so it would fit under the dash of the family automobile, yet it includes almost all of the operating features of the rig in the shack. Six-band operation, fone or CW, v.f.o. or crystal control, with provision for zeroing-in on a signal, push-to-talk, complete band switching, and single dial tuning, up to the pi-network output.

The power input is a clean 15 watts that requires no elaborate power supply. The battery drain is low and the ordinary car generator can easily take care of it. It is designed to operate from two small vibrator power sup-

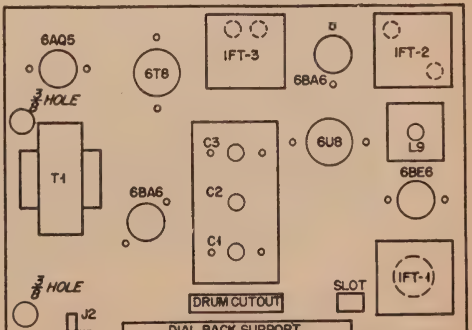


Fig. 73. Layout plan for the top of the receiver chassis.

Receiver Voltage Measurements

TUBE	PIN NUMBER—VOLTAGE								
	1	2	3	4	5	6	7	8	9
6BQ6 r.f.	-.75	0	0	6	180	50	0		
6U8	100	-2	35	0	6	150	0	0	-.75
6BE6	-1.5	0	0	0	225	75	-*		
6BA6 i.f.	-*	1.5	0	6	210	80	1.5		
6T8	-1	-*	+*	0	6	-1	0	-.5	
6AQ5	0	15	0	6	210	225			

All measurements taken with a Simpson model 260 VOM 20,000 ohms per volt. Polarity is positive with respect to chassis ground unless otherwise indicated. Voltages marked (*) are too small to be read with any significance other than to show probable correct operation by polarity of reading. Source voltage was 225 and total current for the receiver is about 60 ma. at this voltage.

Figure 74.

plies, or dynamotors, or one of each, or what have you? One supply can be the auto receiver —it is not used for anything when transmitting anyway. The final and modulator of the transmitter are powered from any separate source putting out about 300 volts at 100 ma., or the entire rig can be operated from a single 300-volt supply if the 160 ma. current is available. Front view of the transmitter is shown in *Figure 75*.

The entire transmitter is built on a 7″x9″x2″ chassis with a front panel 5 inches high. It slides into a home-made cabinet that is fastened under the dash of the car. All controls are on the front panel. The main dial is calibrated on a piece of white cardboard, covered with a sheet of plexiglas to protect it from damage or warping and fastened to the front panel with small bolts. The pointer is attached to an extension of the tuning condenser shaft protruding through the front panel. The dial drive is done by means of concentric discs taken out of a surplus "beacon" receiver. The meter is a surplus unit shunted to read 0-75 ma. full scale and it is switched to read modulator and final plate current—very necessary in tuning up a pi-network. The two jacks on the lower left side are for mike and key, the mike jack being the small shaft type and the key jack a standard ¼-inch size so no mistake can be made in putting in the plugs. One toggle switch (*Sw8*) is for zero-beating a signal (it applies voltage to the oscillator only) and one (*Sw9*) is for fone-CW operation. The crystal socket is recessed to protect the crystal from being bumped out of the holder. Below the dial is the bandswitch and the two controls on the right side of the panel are plate tank tuning (*C25*) and pi-network output tuning (*C28/C29*). A switch on the microphone energizes the antenna change-over relay. This relay has a second set of contacts which are used to apply receiver B-voltage to the low power stages, while an external relay on the dynamotor (or power pack) applies plate voltage to the final r-f amplifier and modulator.

The tube line-up of the transmitter is: 6AU6 v.f.o. or crystal oscillator, 6AH6 buffer-doubler, and a 5763 class-C amplifier which runs "straight through" on all bands. An OA2 is included in the oscillator plate supply circuit to regulate the oscillator supply voltage. The modulator comprises a pair of 6AQ5 tubes in Class AB, with a 12AT7 speech amplifier working from a carbon microphone. Speech frequencies are emphasized by a small coupling condenser (*C31*) between the voltage amplifier stages, and a small cathode bypass condenser (*C32*).

Gang tuning is used for the exciter stages, and the final stage is tuned separately for ease in antenna matching over the wide frequency range of the transmitter. The idea of gang tuning is to maintain uniform grid drive to the

Fig. 75. Six band VFO mobile transmitter employing a 5763 pi-coupled amplifier modulated by two 6AQ5 tubes, this miniature transmitter runs 15 watts input on all bands, 80 meters to 6 meters. Front panel size is 9″ x 5″.

final amplifier over the entire range of each band. This is easily accomplished on the lower frequency bands, but above 21 Mc. actual tuning of the exciter circuits becomes essential —hence the addition of the third variable condenser *(C3)* to the tuning gang. This small variable unit is just sufficient to resonate the higher frequency circuits so that grid current to the final remains constant when the transmitter is tuned across an entire band.

Oscillator Circuitry

The v-f-o circuit used is one that is particularly suited for mobile operation, or for use in limited coil space. Coil *"Q"* is not critical and stability is achieved by using silver mica and *NPO* type condensers, as well as a ceramic switch and tube socket. As with any v-f-o, care must be taken to use heavy connecting wires, short leads and rigid mounting of all parts to insure freedom from vibration. Experience has shown this transmitter to be more stable than any present day mobile receiver against which it has been compared.

Three separate oscillator coils (*L1, L2* and *L3*) are used to simplify setting the tuning range, and to enable the use of common crystals—the crystal in use corresponding to the frequency range of the oscillator grid coil. For crystal operation, the v-f-o dial is set to the approximate frequency of the crystal, the switch placed in the "crystal" position, and all circuits right up to the final are then completely tuned and ready to operate. It will be noted from the schematic that the tuning condenser (*C1* and *C2*) is used for two purposes. The two sections are switched in parallel to make 50$\mu\mu$fd. capacity to spread the 3500-4000 kc. range over 180 degrees of the dial. The next oscillator coil (*L2*) tunes from 7000 to 7425 kc. using only ½ of the dual condenser (25 $\mu\mu$fd.) so that the ten-meter band is spread over the 180 degrees of the dial. This range is used for the 40, 20, 15, and 10-meter bands, frequency multiplication being done in the plate circuit of the oscillator or the buffer-doubler stage as required. These bands are all in harmonic relationship so the calibration on the dial for 40 meters is about 120 degrees and for 20 and 15 meter bands somewhat less than 90 degrees.

The third oscillator coil (*L3*) operates from 8333 kc. to 9000 kc., tripling in the oscillator plate to 25-27 Mc. and doubling in the 6AH6 stage to 50-54 Mc. Note that the second half of the dual condenser (*C2*) is switched over and used as a plate tuning condenser for the two highest ranges covered by the plate circuit of the oscillator, thus maintaining uniform grid drive to the buffer stage. Coil *L4* is untuned, but made broadly resonant just outside the 40-meter band so that adequate drive is delivered to the 6AH6 for doubling to 14 Mc. and tripling to 21 Mc.

The use of separate coils for each band in

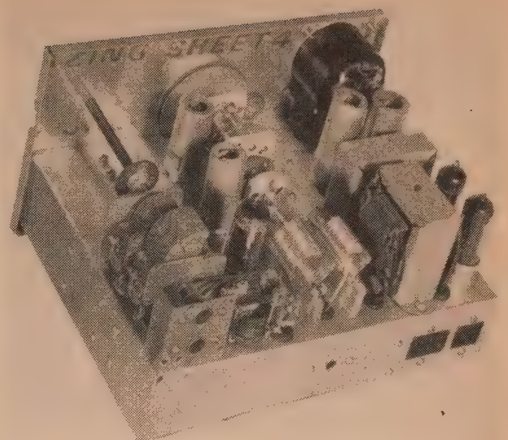


Fig. 76. Rear view, VFO transmitter. The r-f section of the transmitter is at the left, with the pi-network condenser and the antenna change-over relay in the foreground. At the center, are the r-f coils for the 5763 stage (L13 and L14). To the right is the audio section. Placement of all parts is shown in Figure 77.

the plate of the 6AH6 buffer-doubler makes the construction easier and simplifies adjustment for tracking. Any one band can be worked on without affecting the others and since the drive will vary from band to band, it permits loading the individual coils with resistance values to obtain the proper amount of grid current to the final for each band. The same thing is done in larger rigs by varying the screen voltage of the driver tube with a potentiometer. Once the final grid current has been adjusted for each band, it requires no further attention and no provision is made to read grid current on the meter. However, in order to make the initial adjustments, provision is made to read the grid current of the 6AH6 and the 5763 by dividing their grid resistors in two parts (*R3/R4* and *R11/R12*). The two resistors are pig-tailed together, this junction being made to project up from the socket to form test points *"T"* for the attachment of an external test meter to read grid current during the lining up process.

Final Amplifier Coils

The final tank coils (*L13* though *L16*) are made from *Air Dux* or *B&W Miniductors* using a combination of single and tapped coils. The 80-meter coil (*L13*) is separate so additional capacity can be added directly to the circuit to obtain the proper *L* and *C* ratios for antenna matching. The two low-frequency coils *(L13-L14)* are mounted on the top of the chassis using a ¼″ thick bar of polystyrene stock ½″ wide and slightly longer than the coils. The coils are glued into a slot in the bar with coil dope and the bar drilled and tapped for mounting bolts and the whole assembly then bolted down to the chassis. The

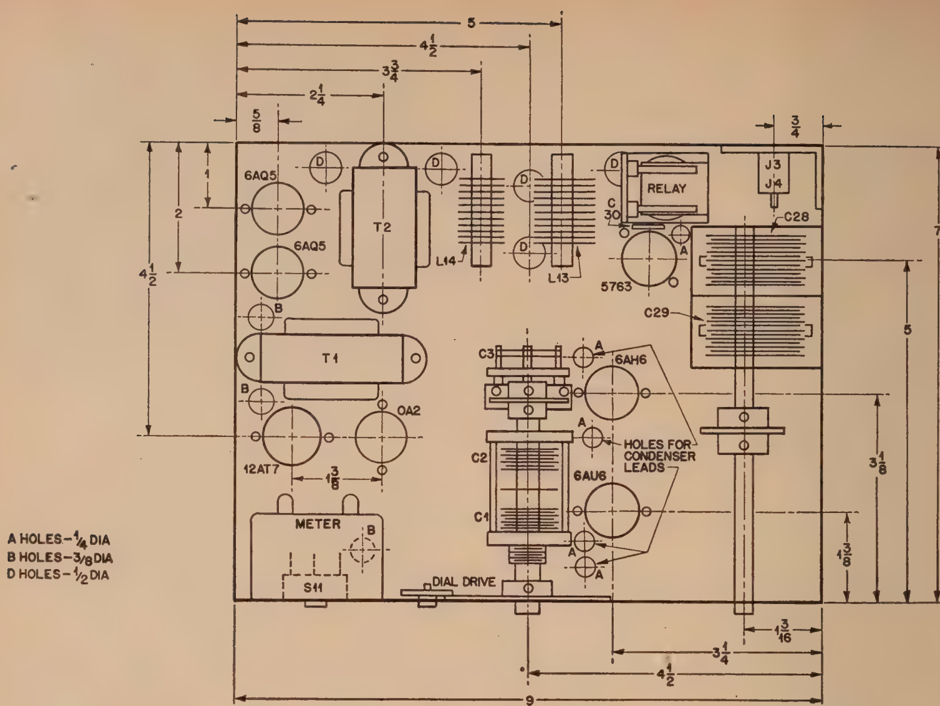


Fig. 77. Placement of above-chassis components of transmitter.

coil leads are brought down through grommetted holes in the chassis to the bandswitch just below. The two high-frequency coils *(L15-L16)* are mounted in the space between the switch wafers under the chassis, being fastened right to the switch contacts. They also have small polystyrene blocks glued between coil and chassis to support them and take the strain off the switch contacts.

The final tank condenser (*C25*) should have more capacity for the lowest bands, but a compromise is necessary to make tuning of the higher bands less critical. The antenna loading condenser (*C28-C29*) is a dual section midget broadcast type with the sections in parallel (and the trimmers removed) to make a total capacity of about 700 $\mu\mu$fd. The mounting of the final tank and antenna loading condensers was carefully figured out for short leads and direct ground returns to the cathode of the final tube. The loading condenser is mounted on top of the chassis, but it is insulated from the surface with a thin sheet of bakelite. It is fastened with bolts coming from the underside of the chassis through holes large enough so that the bolts do not touch the metal, but make contact only on the underside of the chassis. The tank condenser is directly under the antenna condenser and right next to the final tube socket. The *Cardwell* condenser used in this model is mounted on a home-made bracket, but a *Bud* or *Hammarlund* condenser of the same kind has mounting legs that can be bolted to the side of the chassis. The condenser grounds and the screen and cathode bypass condensers connect to one common ground point on a lug under the bolt holding the tube socket. Keying is done in the cathode of the final and switch, *Sw9,* shorts out the secondary of the modulation transformer and removes voltage from the modulator.

Complete data for all coils is given in *Figure 78.*

Transmitter Assembly

Chassis layouts for the transmitter are shown in *Figures 77* and *81,* and top and bottom photos showing parts placement are given in *Figures 76* and *79.*

This rig is small and compact, but not complicated to build. The small size is obtained by careful layout and the use of many new small components. The bandswitch is made from individual ceramic wafers of *Centralab's miniature 2000 series,* each section having one pole and 12 positions, although only six positions are used. Two pole sections could have been used, but the wiring job is lots easier with one pole wafers. The wafers are mounted on the coil partitions with bolts and spacers. A shaft for the switch is made from a 7-inch length of 1/4" diameter fiber rod filed flat on two sides to fit the slot in the pole piece of the switch wafers. Flat fiber shafts are made commercially, but they may be a little hard to find. A metal shaft is not advisable since undesired coupling between driver tube and final should be avoided. Also, we want as little metal as

possible in the field of the final coils that mount between the switch wafers.

Three internal partitions are made from sheet aluminum (22 gauge), or cookie-sheet material. A drawing of these partitions is given in *Figure 80*. One partition fits the entire length of the chassis (the inside length is slightly less than 7″) and has ¼″ lips bent on all sides for strengthening and providing mounting brackets. When this passes the oscillator compartment it is used for mounting two of the oscillator trimmer condensers (*C5, C6*). This partition is made only 1⅝″ high so that the trimmers will not extend beyond the depth of the chassis. The two partitions dividing the coil compartment are made exactly the same way except that they are shorter. Cutouts are made on the bottom side of these partitions for the wiring to pass through where required. The front apron of the chassis is drilled to match mounting holes for the controls. The coil partitions are marked accordingly for mounting the switch wafers in a line with the switch index which mounts on the front apron. A hole is drilled through each partition to allow the extension shaft of the final condenser to pass through. Cutouts are made in the bottom of the partitions in line with the tube sockets for the filament wiring and the coupling condensers.

Accuracy is required in mounting the switch wafers on the partitions so that the switch will operate smoothly. A ¼″ hole is drilled in the rear apron of the chassis directly in line with the index mounting hole so that the switch shaft can be inserted from the rear, slid through all the wafers and fastened to a shaft coupling on the index. Switch *Sw7* is also mounted on the rear apron with bolts and spacers. All switch wafers are oriented so that the six contacts used appear on the top where they can be easily reached with the soldering iron for making connections to the coils.

A small bracket is made of some aluminum sheet material to mount the recessed crystal socket behind the cutout in the front apron. Fastening this bracket requires countersunk flat head bolts, so the panel will fit flush against the front apron of the chassis when it is put on. An aid in fastening all partitions and brackets is to tap the mounting holes drilled in them so that they may be attached to the chassis with stud bolts—saves a lot of time and trouble trying to put on nuts in tight spots.

Dial Drive

The *Bud* dual "Tiny-Mite" has two substantial mounting feet and these are used to fasten it to the chassis right down the center line with enough of the shaft extending beyond the front of the chassis to attach a pointer after the panel is put on. For this particular dial drive system, a slot is cut out in the chassis large enough for the large disc to extend below the surface. The little driving disc mounts through a bushing on the panel itself. Its exact location must be found by trial since the tuning knob has to be out of the way of the calibrations on the dial, yet the discs must be close together to get a smooth turning drive. A small bracket is made to mount the modified *APC* condenser in line with the rear extension shaft of the "Tiny-Mite." They are ganged together with a regular insulated shaft coupling. Another small bracket is made to mount the two pin type jacks flush with the rear of the

Fig. 78. COIL DATA

Coil	Turns	Wire Size	Diameter	Winding Length	Tuning Range
L1	36	24	¾″	1″	3500 - 4000 kc.
L2	19	24	½″	¾″	7000 - 7425 kc.
L3	17	24	½″	¾″	8333 - 9000 kc.
L4	53	30	½″	¾″	Resonates 6900 kc.
L5	12	24	⅜″	¾″	14 Mc.-14,850 kc.
L6	6	20	⅜″	¾″	25 Mc.-27 Mc.
L7	95	32	½″	⅞″	3500 - 4000 kc.
L8	45	30	½″	¾″	7000 - 7425 kc.
L9	25	24	½″	¾″	14,000-14,850 kc.
L10	16	24	½″	¾″	21,000-22,275 kc.
L11	15	24	⅜″	¾″	28,000-29,700 kc.
L12	7	20	⅜″	¾″	50,000-54,000 kc.
L13	31	B&W 3016	1″	1″	80 meters
L14	32	B&W 3012	¾″	1″	40-20 meters
		(Tapped 17 turns from cold end)			
L15	12	B&W 3011	⅞″	¾″	15-10 meters
		(Tapped 5 turns from cold end)			
L16	6	16	½″	1″	6 meters

L1 is wound on a ceramic form that has threaded holes at both ends for mounting.

L2 through L12 are wound on 1¼″ lengths of polystyrene rod drilled and tapped at one end to take a 4-36 mounting bolt. A small hole is drilled at the opposite end through the diameter of the form to hold the end of the wire and a similar hole is drilled ¾ inches down the form to hold the opposite end of the winding.

L7, L8 and L9 have a second set of holes drilled next to the wire mounting holes for the loading resistors.

L13, L14, L15, and L16 are mounted on polystyrene bars which bolt to the chassis, as explained in the text.

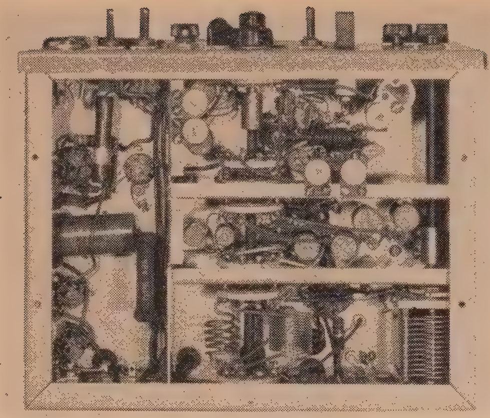


Fig. 79. Under-chassis view of mobile transmitter. The aluminum partition of Figure 80 divides the under-chassis area into four compartments. The audio section is to the left, and the three r-f sections to the right. See Figure 81 for placement of major components.

chassis behind the antenna loading condenser. Mounting holes for the tube sockets, transformers, and final coils are then made and all components mounted on the top of the chassis. The mounting holes in the front apron of the chassis are used as a template to mark the panel, which is fastened to the chassis by the same nuts holding the controls.

Wiring

The wiring is done next, putting in all voltage supply circuits, by-pass condensers, and resistors. Most of these mount right at the tube sockets. The cathode by-passes in the modulator (*C32* and *C33*) are mounted vertically along the side of the chassis. The audio system is simple and requires no particular caution in wiring. The transformer leads are brought to the underside of the chassis through grommetted holes, as are the leads to the meter switch (*Sw11*), relay, and the tuning condensers. The long partition is installed and much of the wiring is placed along the modulator side of this partition while the r-f voltage supply leads run through the holes cut in the bottom of the partition over to their respective part of the r-f section. Tie points are used where required so that all parts are securely fastened—always a good idea in a mobile rig.

Before putting in the coil partitions, the oscillator coils are installed and this whole section wired up. The first partition is then bolted in place so that the oscillator plate coils may be wired to the switch contacts. At this point voltage can be applied to the oscillator using a test bench power supply with enough voltage to ignite the OA2 regulator tube. Using a receiver as a monitor, the tuning range of the oscillator coils can be set by adjusting the trimmers. With the 6AH6 tube in place (but with no plate voltage on it) a 0-1 milliammeter is attached to the 6AH6 grid test point and the oscillator plate coils checked for tracking. 80 and 40 meters present no problem since there is a choke in the plate of the oscillator on these frequencies and any indication of grid current (½-1 ma.) shows that it is

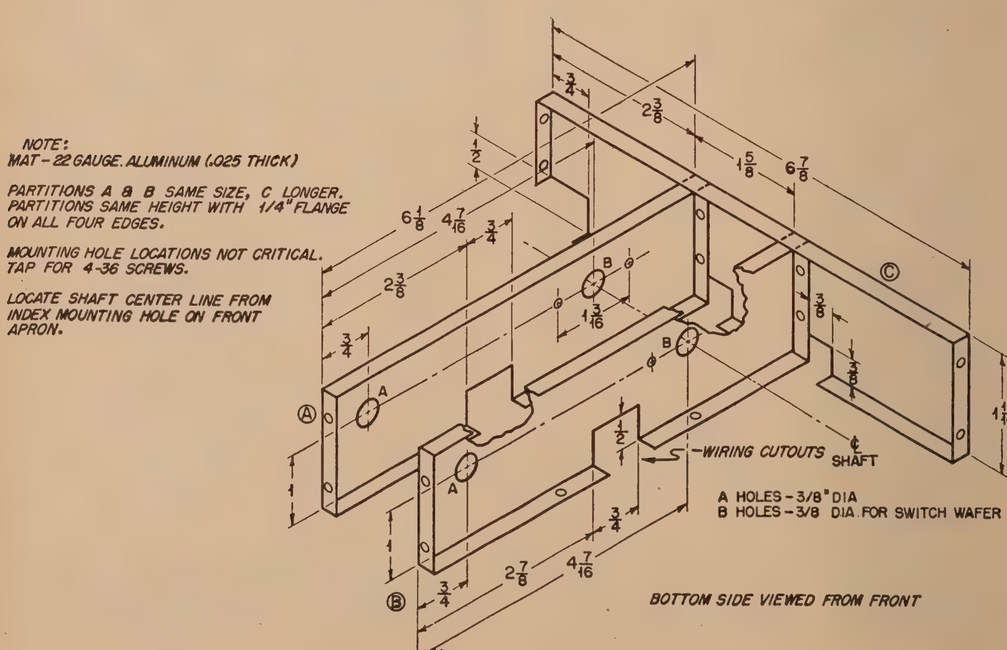


Fig. 80. Partition dimensions. See Figure 81 for exact placement under the chassis.

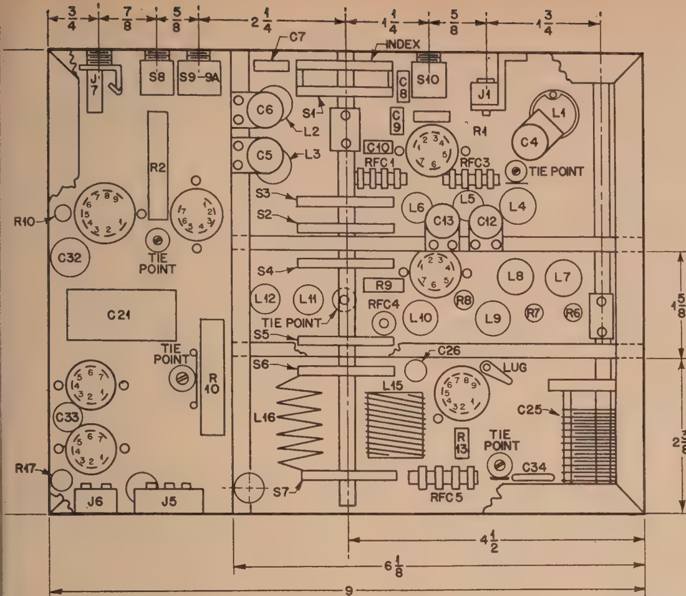


Fig. 81. Under-chassis parts diagram.

working properly. The same is true for the 20 and 15-meter positions where the grid current may be even more than 1 ma. It is only necessary to determine with an absorption wavemeter that the output is on 40 meters. This coil should be resonant just below the 40 meter band and can be checked with a grid dip meter when no voltage is applied to the oscillator.

Coil *L5* can now be adjusted for tracking to cover the frequencies indicated in the coil table. With the tuning condenser set at the high end of the band, the trimmer is peaked for maximum grid current to the 6AH6 and the condenser then tuned to the low end of the band. If the grid current does not change more than a few tenths of a milliampere, that is all there is to it. It is advisable to check with a wavemeter or grid dipper to be sure the right harmonic is being used. If the grid current falls off, the turns on the coil will have to be spread or compressed slightly to bring it back up to the original reading, and the tuning process repeated until the grid current remains constant. Coil dope is used to hold the windings secure when the alignment is completed. With the band switch in the 6-meter position, coil *L6* is adjusted for tracking in the same way to cover a range of 25 to 27 Mc.

Before going ahead with the buffer coils, the dial is marked lightly in pencil at the band edges so the frequency coverage can be referred to during the balance of the alignment. The second switch partition is fastened in place and blank coil forms placed in position in the compartment so their mounting holes can be marked. An ⅛″ hole is drilled through the chassis under the position for each coil to enable mounting with stud bolts. The final tank coils are installed and all final r-f wiring completed before going ahead with the alignment of the buffer coils. After the plate and B+ connections have been made to the buffer switch section arms, the buffer coils are installed and aligned—the easiest way being to take one band at a time starting with the 6-meter coil. A rough check can be made of coil tracking by using a grid-dip meter, but the best coil adjustment is made under operating conditions using the test bench power supply.

Since the rig is designed only for 6-volt operation, the relay contacts have to be closed with a piece of cardboard to get voltage through the power plug. A 0-10 ma. meter is connected to the test point in the grid of the 5763 and about 250 volts applied to *pin 4* of the power plug. Switch, *Sw9*, should be in the CW position to keep voltage off the modulator. The dial is set about mid-scale (or about 52 Mc.) and the six-meter buffer coil turns spread or squeezed together as required to get a maximum grid reading to the final. This will be about 3 or 4 ma. The tuning condenser is then run over the whole band to check for uniformity of grid current. If there is any great variation, adjust the coil turns for uniform current for the full range of tuning.

Loading Up

Before going to the next band, operating conditions should be checked with power applied to the final. A dummy load is used (15-watt light bulb on the end of a piece of co-ax plugged into the antenna jack) and final voltage is applied through *pin 3* of the power plug, using the same 250-volt supply. When the final is resonated and loaded, the grid current will fall off slightly and the turns of the buffer coil will have to be readjusted to bring the current

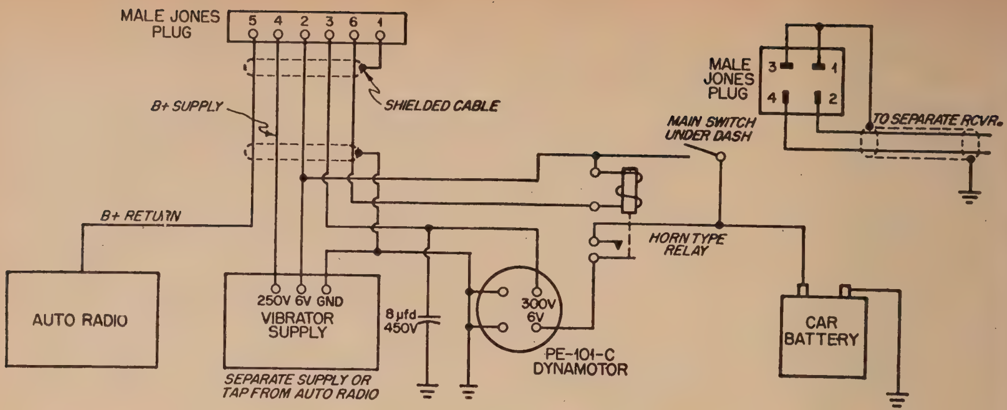


Fig. 82. Power and control wiring for the "Six Bander."

back up to maximum. When all checks have been made, the grid current should be in the neighborhood of 2½ to 3½ ma.—the objective being to get 3 ma. operating current on all bands. Some variation one way or the other is not too important.

The 10-meter buffer coil can now be wired in place and the same process repeated to align this band, going to the next lower band and so on until all the bands are lined up. The three lowest bands are not at all critical and coil adjustment is made by adding or taking off a turn of wire. These coils are loaded with resistors to keep from overdriving the final. The operating grid current should be adjusted for the same 3 ma.

A metal bottom plate is used on the chassis so possible vibration of the cabinet will not affect the oscillator. This bottom plate should be in place when the final checking is done and the dial is calibrated. The trimmers are reached through holes made in the bottom plate. Dial calibration is made by putting voltage on the oscillator only and beating the signal on a receiver of known accuracy.

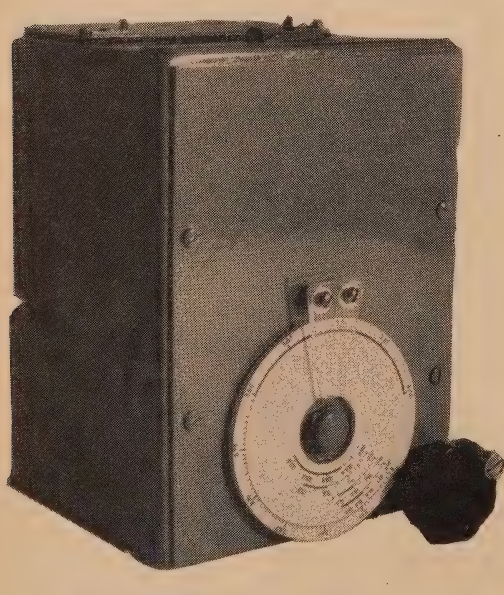


Fig. 83. This stable master oscillator is made from a "cut-down" SCR-274N "Command" transmitter.

The cabinet is made from one long sheet of aluminum 7⅛″ wide and 29″ long bent to make the cabinet 9¼″ wide, 5″ high and 7⅛″ deep. It is slightly wider than the chassis to give clearance to the heads of the mounting bolts on the side of the chassis. The back piece for the cabinet and the panel are identical in size and are made 5″x9¼″ with a ⅜″ lip turned back on all four sides to fit over the outside ends of the cabinet. The back is fastened on permanently with rivets or bolts and cutouts made for the power plugs and antenna connections. The panel is mounted on the chassis and when the rig is slid into the cabinet, bolts are screwed through the side lips on the panel to hold the transmitter in the cabinet.

Actual final amplifier operating current is 50 ma. with a 300-volt power supply. Modulator resting current is about 45 ma., kicking up to 60 ma. with voice modulation. A suitable control circuit schematic for this transmitter is shown in *Figure 82*.

a Mobile VFO

A simple and highly efficient mobile v-f-o unit may be made from the oscillator section of a 3-4 Mc. "Command" transmitter, as shown in *Figure 83*. The rear section of the transmitter is cut off from the front of the chassis and modified to form a v-f-o having high stability and good resetability. The circuit of the revised v-f-o is shown in *Figure 84*, and rear and bottom views of the converted unit

are given in *Figures 85, 86* and *87*.

The Conversion

The first step is to remove the top and bottom covers of the "Command" transmitter, and all the wiring beneath the chassis deck. Next, remove the two power amplifier tube sockets, the flexible tuning shaft, the power amplifier padding condenser (the one not attached to the tuning shaft), the power amplifier tank coil, and the r-f choke. Remove the dial, window frame, and all projecting hardware and knobs from the front panel. Grind or drill the heads of the rivets which hold the front panel to the chassis down to where they can be punched out with a center punch.

Remove the front panel and cut a piece of 1/16″ sheet aluminum to fit over it as a false front. In this false front cut a 2″ diameter hole to clear the tuning dial hub, and a hole in the lower right corner just large enough to clear the tuning shaft. Mount the false front on the front panel by means of 6-32 screws.

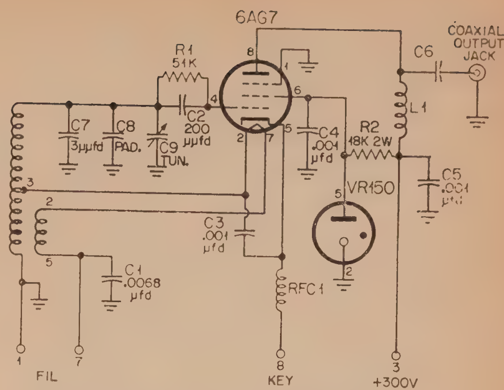
The oscillator tuning condenser (from below the chassis) can be removed and added to your junk box. Remove the p.a. tuning condenser with its associated gears. Use care, for this condenser will be used to replace the oscillator tuning condenser.

With a husky pair of tin snips or a hacksaw you can now cut the chassis down to 4½″ depth. The cut will come about ⅛″ ahead of the rear edges of the two p.a. socket holes. Remember, you are using the rear part of the chassis, not the front.

Mount the former p.a. tuning condenser in the space left vacant by removal of the oscillator condenser. Try the front panel on for fit. There should be sufficient clearance between the front panel and the gears to permit them to turn freely. Once this clearance has been established the panel can be secured to the sides of the chassis by means of "C" clamps. Drill and tap through the rivet holes, then mount the panel on the chassis with ¼″ 6-32 screws. Top and bottom covers should be cut to size.

The former crystal socket should be removed, and the hole covered by a 1⅛″ square piece of 1/16″ sheet aluminum. The power socket on the rear of the chassis should be replaced with an octal socket. A coaxial chassis-type connector should be installed beside the octal socket. Using the oscillator tube socket for the 6AG7, and the "magic-eye" socket for the VR-150, wire up the unit as shown in the schematic.

The output coil is mounted in the former crystal socket space with the adjustment screw upward, as shown in the photographs. Use solid No. 14 wire for all leads between the 6AG7 and the oscillator tank circuit. The 6800 μμfd. bypass condenser, the 51,000 ohm grid leak, and the 200 μμfd. grid condenser, are original parts. Use short direct leads, especially on the 1000 μμfd. ceramic bypasses.



NOTE: C1, C2, C7, C8, C9, & R1 ARE ORIGINAL ARC-5 PARTS. .001 CONDENSERS ARE 600 V CERAMIC.

R1—51,000 ohms.
R2—18,000 ohms, 2w.
RFC1—2.5 mh. r-f choke.
L1—3.5 mc., 20 turns #28 enam. closewound on National XR-62 form.

C1—6800 μμfd.
C2—200 μμfd.
C3, C4, C5—1000 μμfd.
C6—1000 μμfd. 600v. mica.
C7—3 μμfd.
C8—Oscillator padder.
C9—Former p.a. tuning condenser.

Figure 84.

When all connections have been made, the unit is ready for test. A 24″ 4-conductor power cable should be made up to connect the VFO to the transmitter. A source of 300 volts plate power and 6.3 volts filament power will be required. A 24″ piece of RG-59/U coaxial cable is used as the r.f. connection to the transmitter.

Put back the old dial, and the tuning shaft knob. Set the dial at 4.0 Mc., and loosen the screws which hold the shaft of the oscillator padding condenser on top of the chassis. Replace the oscillator cover and fasten it down with several screws.

Turn on the power, and after warm-up, adjust the oscillator padder until the signal is heard in the station receiver at 4.0 Mc. Set the v-f-o dial at 3.5 Mc. and check the calibration. The band-spread may be adjusted by means of the oscillator tank coil slug and the padder condenser. When the tuning tracks satisfactorily, the padder shaft can be locked in position, and the covers replaced and secured with all screws. Fine adjustment may now be made with the trimmer at the top of the condenser, and the slug.

For those who are interested only in the 3.5- to 4-0 Mc. band, the unit may now be considered complete. The slug-tuned output coil *L1* may now be peaked for maximum grid drive to the transmitter. The capacity of the co-ax cable forms a part of the output circuit. Should a different length of cable be used, it will be necessary to adjust the number of turns in *L1* accordingly to insure resonance in the 3.5 to 4 Mc. band.

This particular v.f.o. was used on 14- and 21-Mc. 'phone most of the time, so it was deemed desirable to make a new dial, and to

spread the 3.5- to 4.0-Mc. band over about 330 degrees of rotation, to avoid cramped readings at the higher frequencies.

To accomplish this band spread, first remove 9 rotor plates from the bearing end, and 1 rotor plate from the gear end of the oscillator condenser. This leaves 6 rotor plates. This can be done with a pair of long-nose pliers. Be careful not to disturb the stator or to dislodge the pyrex bead insulators. Adjust the padder condenser until 3.5 Mc. appears at the low end of the tuning dial, and 4.0 Mc. at the high end. The exact location of these points relative to the old dial scale is not important, as we have to make a new dial scale.

Remove the old dial. Using a piece of ⅛″ lucite, cut a circular piece 3¼″ in diameter, and another one 1¾″ in diameter. The larger piece is the dial face, and the smaller one the hub. Cut a 1″ hole in the dial face, and using the old dial as a template, cut a hole in the center of the hub to fit the dial mounting. Drill the hole for the alignment pin. Try the hub for size on the dial mounting. The face may be cemented to the hub at this time, using Duco cement.

Using small spots of rubber cement, secure a piece of heavy white paper or cardboard to the dial for a scale, and calibrate the new scale using the station receiver and frequency meter, marking the calibration right on the paper. Begin at 3.5 Mc. and make a small mark every 5 kc. The 50 kc. points should be marked with figures, such as 3.50, 3.55, 3.60, etc. Mark the 3.5-Mc. and 4.0-Mc. points on the edge of the lucite. With the aid of a draftsman, the marks and figures may be neatly inked in, with the paper scale removed from the dial.

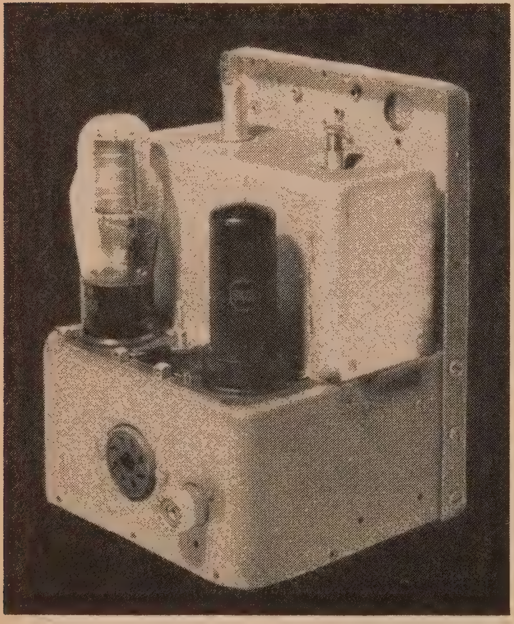


Fig. 85. VFO: Rear view with cover removed. The slug of L1 projects between the GaG7 oscillator and the voltage regulator tube.

The other amateur bands may be shown in the proper harmonic relationship, as shown in *Figure 88*. The 'phone bands may be shown by heavy inked lines. This figure is not intended to be an accurate calibration but is merely included as a guide to the reader. After the inking is done, the scale may be cemented to the dial face by means of Duco cement, and the whole dial should be sprayed with Krylon clear plastic spray to protect it.

The calibration should be rechecked, with the oscillator padder locked and the covers in place and secured with all screws. Slight variations in calibration can be made with the slug and trimmer.

The VFO unit, from its 3.5 to 4.0-Mc. output, will give sufficient excitation to drive most transmitters on all bands from 3.5- to 28-Mc. The frequency stability is exceptionally good.

a 20 Watt VFO All-band Mobile Transmitter

A compact VFO phone transmitter designed for all-band operation is illustrated in *Figure 89*. The r-f section of the transmitter, including the v-f-o is mounted beneath the dash of the automobile. The mobile converter and a transmitter control box are mounted to the steering column. Hidden away beneath the hood of the car are the modulator and power supply unit. The transmitter runs 20 watts input to a 2E26 tube on all bands between 80 and 10 meters. A high level audio filtering system is employed in the audio section of the transmitter to limit sideband splatter caused by higher order harmonics of the modulator.

Transmitter Circuit

A block diagram of the complete installation is shown in *Figure 90*. Three separate units are employed: a r-f unit (shown in *Figure 89)*, a control box (also shown in *Figure 89)*, and a modulator-power unit (shown in *Figure 95*). These three units are interconnected by means of two 8-wire cables, and a shielded microphone lead. Primary power from the automotive electrical system is routed to the control box and from there to the r-f unit and the modulator-power unit.

The schematic of the r-f unit is shown in *Figure 91*. The circuit consists of a 6AU6 electron coupled oscillator operating in the 80-meter region. The output of the oscillator

is fed to a doubler string consisting of two 12AU7 twin triodes. Each section of each tube acts as a frequency doubler, providing proper excitation for the 2E26 to run as a class-C amplifier on all bands. The heart of the doubler circuit is the *"Labgear" Wide-Band Multiplier* unit. This piece of equipment is relatively new in W-land, although it has been used extensively in Europe. It is built by *Labgear Ltd., Willow Place, Cambridge, England.* The wide-band multiplier unit consists of a series of band-pass stages, each one tuned to a different amateur band. The schematic of this unit is shown in *Figure 93.* When employed with two 12AU7 tubes operating at 250-300 volts, and supplied with a few volts of r-f at 80-meters, the unit will supply correct excitation for a 2E26 or 807 in any amateur band between 80 and 10 meters. Since each band is covered by a band-pass circuit, no tuning of the multiplier unit is necessary as the operating frequency is varied across the amateur band.

The plate circuit of the 2E26 employs a simple pi-network to allow coupling to an unbalanced coaxial line feeding a low impedance antenna load. A v-h-f filter is placed in the B-plus lead to the 2E26 tube to reduce the harmonic currents that might otherwise flow back through the plate supply system. The 2E26 normally operates at an input of 300 volts and 70 milliamperes (21 watts).

Figure 94 shows the schematic of the modulator-power unit. Two 12AX7 tubes are employed as a class B modulator. The elements of each tube are strapped in parallel, and the tubes operate in a zero bias condition. A 12AU7 is parallel-connected as a class A driver stage, transformer coupled to the two 12AX7 tubes. A second 12AU7 tube serves as a two stage resistance coupled audio amplifier. The modulation level control is placed in the grid circuit of the second half of the 12AU7 voltage amplifier tube.

To reduce sideband "splatter" a high level filter is placed between the modulator stage and the 2E26 r-f amplifier. This filter is designed to provide substantial reduction of all audio frequencies above 3500 cycles.

A surplus PE-101C dynamotor is used to provide 300 volts at 150 ma. for the entire transmitter. When the dynamotor is run on 6-volts (with no modification of the armature) it is possible to obtain a low voltage on the order of 160 volts, and a somewhat higher voltage, in the region of 300. The various modifications of this dynamotor are covered in Chapter 3 of this Handbook. The PE-101C dynamotor is mounted directly upon the modulator chassis, and the whole assembly may be mounted beneath the hood of the car, as shown in *Figure 95.*

The transmitter control box, shown in *Figure 89,* attached to the steering column of the car provides the means to connect the r-f package to the modulator-power unit. A schematic

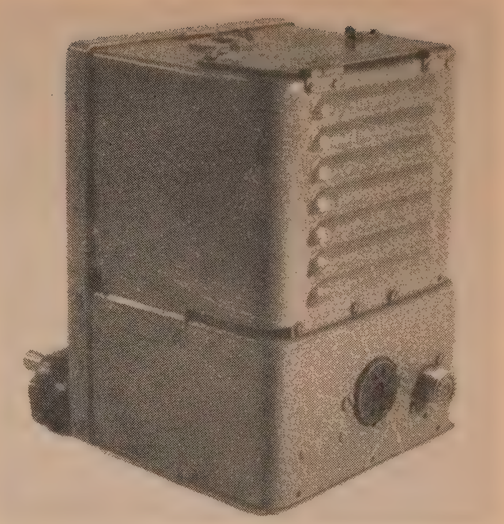


Fig. 86. Rear view of mobile VFO with shield in place.

of the control box is given in *Figure 94.* Two 8-prong receptacles are mounted on the back of the box. These carry the various interconnecting wires between the two transmitter units. A *"Xmtr on"* switch is mounted on the control box. When this switch is actuated, filament voltage is applied to all tubes in the transmitter, and the control circuit is energized. When the control circuit of the microphone is grounded, the main dynamotor relay in the modulator-power unit is energized, applying plate voltage to the transmitter.

Also mounted in the control box are a 3-inch meter and switch allowing the operator to monitor the grid and plate current of the 2E26 amplifier stage. Mounted within the control box are the voltage regulator tube for the oscillator stage and its associated voltage dropping resistor.

Transmitter Assembly

The placement of parts within the r-f section of the transmitter may be seen in *Figure 92.* The complete unit is built *within* an aluminum chassis measuring 10"x12"x3" (*Bud AC-413*). The multiplier unit is laid inside the chassis, with its leads projecting to the left, as viewed from the front. A 3" space is left between the multiplier unit and the edge of the chassis. The top rear lip of the chassis is notched to permit the rear extension of the multiplier bandswitch shaft to pass within the chassis enclosure.

The space to the left of the multiplier contains the 6AU6 variable frequency oscillator and the two 12AU7 multiplier tubes. The 6AU6 tube is mounted horizontally on a shield plate that separates the oscillator section from the multiplier area. The oscillator mounting

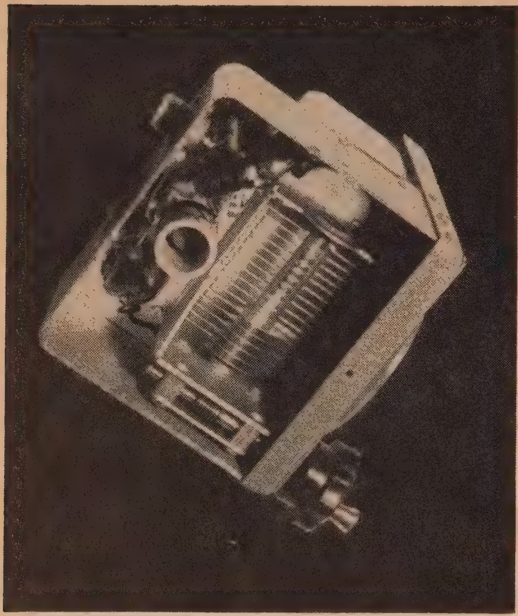


Fig. 87. Under-chassis view of VFO, showing modified tuning condenser.

plate is cut from a 3″x3½″ piece of soft aluminum formed into a 3″x3″ plate having a ½″ lip on the bottom edge. The plate is held firmly in place by this lip, plus a small angle bracket made of aluminum that holds the top edge of the plate to the wall of the chassis.

The two 12AU7 multiplier tubes are mounted on an aluminum deck measuring 6″x1½″, having a ½″ lip along the length of the piece. This plate bolts to the mounting holes of the multiplier unit, and also to the oscillator shield plate. The multiplier tubes are mounted upside down on the long deck, with the multiplier leads passing through grommetted holes in the deck to reach the pins of the tube sockets. The multiplier padding condensers in the grid circuits of the 12AU7 tubes are mounted to the edge of the deck in a vertical position, and may be tuned by a screwdriver inserted through tuning holes drilled in the left side of the chassis. The main power plug is mounted in the rear corner of the chassis, to the left of the multiplier deck.

The space to the right of the multiplier unit is taken up by the components of the 2E26 stage. The 2E26 is mounted in a horizontal position, its socket being fastened to a 4½″x 2½″ deck which is mounted parallel to the front panel, as shown in *Figure 92*. The plate circuit tuning and loading condensers, the p-a band switch, the plate coils and the other plate circuit components are mounted in the large area to the right of the multiplier.

This unusual type of construction results in a complete r-f section that is only three inches high. The extremely small height of the unit permits it to be mounted beneath the dash of most automobiles with a minimum of effort. The v-f-o tuning dial is at the extreme left of the chassis, allowing the driver of the automobile to reach it with a minimum of effort.

Assembly of the modulator-power unit may be observed in *Figure 95*. The PE-101C dynamotor is mounted on the top of a 3″x5″x10″ aluminum chassis *(Bud AC-404)*. The dynamotor starting relay and other power components are mounted within the chassis. The chassis is then inverted, and an aluminum plate measuring 5″x10″ is attached to the open "bottom." The modulator components are then mounted upon this plate, leaving the dynamotor hanging beneath the assembly, in an "upside-down" position. The complete package is then bolted to the frame of the automobile by means of two large chassis brackets, as shown in *Figure 95*.

The control circuits are housed within an aluminum cabinet 3″x4″x5″ in size (*Bud AU-1028*), which is mounted to the right of the steering column by means of an aluminum clamp. If desired, the microphone may be held in position when not in use by a second clamp mounted on the free end of the control box, as shown in *Figure 89*.

Wiring The Transmitter

The bypass condensers, the plate r-f choke, and screen resistor of the oscillator stage are mounted upon the oscillator bracket. The grid circuit components are wired with #14 solid wire to prevent movement of the components under vibration. Switch *S1* is mounted upon the front of the multiplier unit so that the shaft of the multiplier bandswitch passes through the center segment of the switch. Thus when the bandswitch of the multiplier is turned, switch segment *S1* turns with it. This switch segment is held to the front of the multiplier case by means of small metal spacers and 4-40 machine bolts that are screwed into holes tapped in the front of the case.

All the components of the multiplier stages are mounted upon the metal deck holding the two 12AU7 tube sockets. Mounting of these components may be seen in *Figure 92*. All power leads to the oscillator and multiplier sections are run in shielded wire, with the outer braid securely bonded to ground at both ends of the lead.

Switch *S2* in the plate circuit of the 2E26 is mounted on a small aluminum angle bracket affixed to the bottom of the chassis. The two plate coils are mounted to the right of the switch, and are supported by a strip of lucite mounted on two ½″ ceramic insulators. The power leads that run from the 2E26 socket to the power plug are made of shielded wire to lessen the radiation of TVI-producing harmonics. A short length of coaxial line connects the output of the pi-network assembly to the coaxial antenna receptacle mounted at the right rear of the chassis.

After assembly, the open top of the chassis

is covered with a piece of perforated aluminum stock, cut to fit the chassis and held in place with sheet metal screws.

Wiring of the modulator power unit is straightforward. It is only necessary that all power leads to the dynamotor be made of a wire equal to or greater than #*10* to minimize voltage drop in the power leads.

Transmitter Alignment

After the wiring has been completed and checked, the transmitter should be bench-checked with an a-c operated power supply before being placed in the automobile. The r-f section should be checked first. The bandswitch should be set to 40-meters, and the oscillator checked in a nearby receiver. The 45 *μμfd.* padding condenser in the oscillator should be set so as to provide a tuning range of 3.5 to 3.65 Mc. on the vernier dial of the oscillator. This range should occupy almost 180 degrees of the dial. It may be necessary to squeeze or expand the winding of the oscillator coil (*L1*) to achieve this range within the limits of the padding condenser. The dial is now calibrated in the 40, 20, 15 and 10 meter harmonic ranges.

After this range has been set, the bandswitch should be set to 80-meters. On this band, the oscillator covers the range of 3800-4000 kc. Formerly (for 40-meter calibration) the oscillator tuned the range of 3500-3650 kc. Now, the *45 μμfd.* auxiliary padding condenser connected into the circuit on the higher frequency bands is removed by the action of *S1* and the oscillator range is set to 3800-4000 kc by varying the *12 μμfd.* oscillator padding condenser. By adjusting these two condensers, the two separate tuning ranges may be easily set on the dial of the oscillator.

The tuning adjustments of the *Wide-Band Multiplier* are located on the top of the case, and may be reached through holes drilled in the right end of the transmitter chassis-box. Adjustment of these tuning condensers, and of the grid circuit padding condensers is fully covered in the instruction sheet supplied with

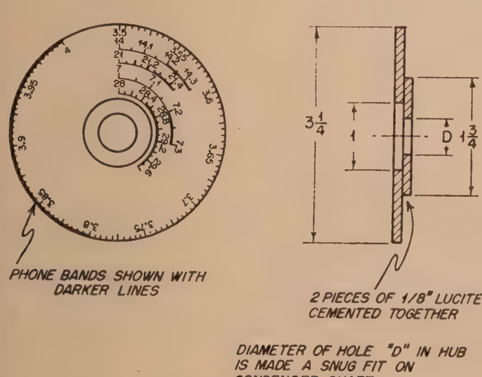


Fig. 88. VFO dial. Note harmonic relationships of bands.

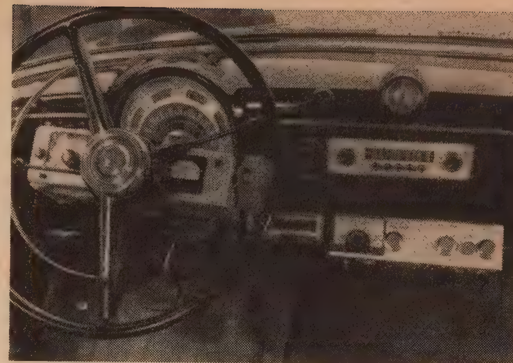


Fig. 89. The transmitter control box mounts to the right of the steering column. The complete 20 watt bandswitching transmitter is mounted beneath the dash of the automobile.

the multiplier unit. The procedure, in brief, is to tune the grid circuits to the low end of the operating range, and the plate circuits to the high frequency end of the operating range. The grid padding condensers are adjusted to compensate for the extra capacity which is present when the stage in use is switched to the p-a grid circuit.

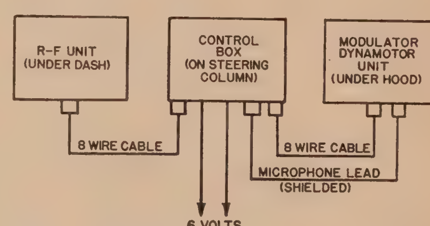


Fig. 90. Block diagram VFO transmitter.

Final adjustment of these circuits may be easily accomplished by observing the grid current to the 2E26 tube and adjusting the multiplier circuits to provide approximately 2 milliamperes of grid drive across each frequency range.

The power amplifier stage may be checked by loading it into a lamp bulb or other suitable dummy load. The exact value of the shunt condensers in the output circuit of the pi-network will have to be determined after the transmitter has been placed within the car. The values shown will do for a starter. If the resonant plate current dip on a certain band cannot be brought down to a value of 70 ma., the particular padding condenser in use on that band will have to be increased in value.

As a final step, the variable resistor in series with the voltage regulator tube (located in the control box) should be adjusted to provide a current through the regulator tube of 15 ma. The v-f-o plate current is about 6 ma., and the multiplier stages draw approximately 35 ma. This value varies from band to band. The

total exciter stage drain is slightly over 50 ma. The class B modulator resting current is 15 ma., rising to about 60 ma. under conditions of 100% modulation. A *Shure 102C* microphone is used with this particular transmitter.

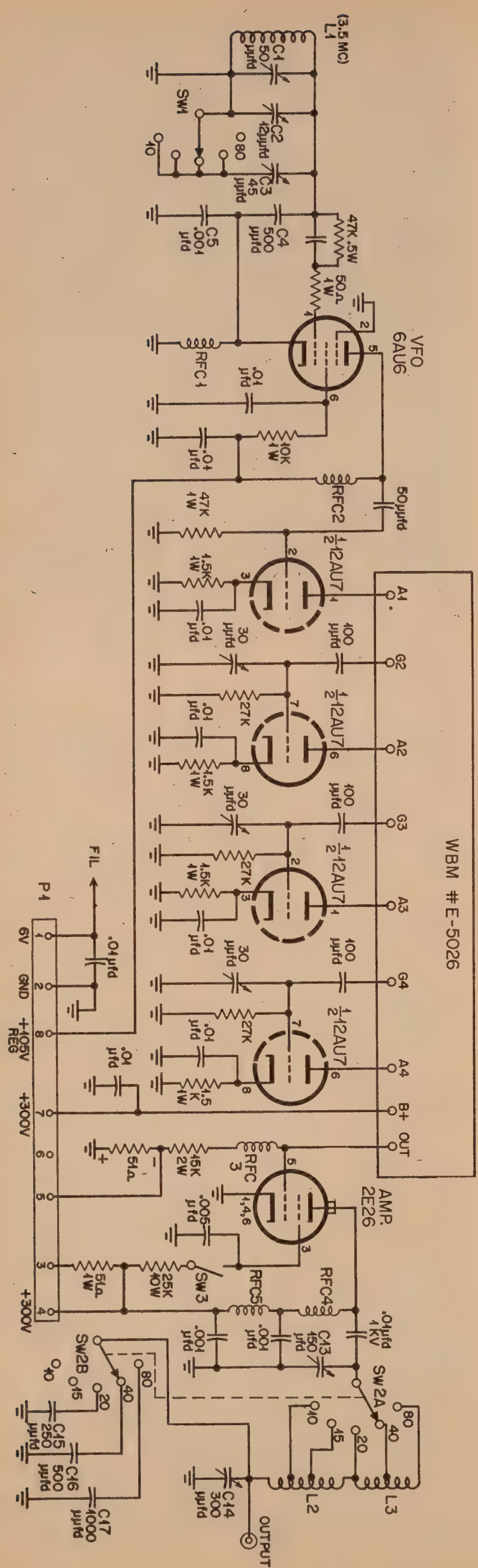


Fig. 91. R-F unit, VFO transmitter.

a Versatile 60 Watt All-band Mobile Transmitter

Shown in *Figure 97* is a 60 watt mobile unit that features low level speech clipping and high and low level audio filtering. This feature, plus all-band operation and provisions for VFO control result in a compact and highly efficient transmitter. The use of speech clipping and filtering allows an unusually heavy degree of modulation of the transmitter without the sideband splatter that accompanies high-percentage modulation of the more common mobile rig. The input level of 60 watts assures that the transmitter can hold its own during periods of heavy QRM. The addition of speech clipping allows a great degree of speech intelligibility even when the received signal of this transmitter is of such a low level as to normally be unusable. With the addition of an external VFO unit, the transmitter has unusual flexibility of operation.

Parts List

C1—50 uufd. Bud MC-1863
C2—12 uufd ceramic. Centralab 822FZ
C3—45 uufd ceramic. Centralab 822AN
C4—500 uufd silver mica
C5—1000 uufd silver mica
C6—50 uufd mica
C7-C9—100 uufd mica
C10-C12—30 uufd variable mica padder
C13—150 uufd. Bud MC-1856
C14—300 uufd. Bud MC-1860
C15-C17—Mica condensers. Adjust capacity of each unit to fit particular mobile antenna in use
All bypass condensers are Centralab type DD ceramic units, or equivalent
RFC1-RFC3—2½ mh. National R-100
RFC4—2½ mh. National R-100U
RFC5—VHF choke. Ohmite Z-144
S1—Single pole, 5 position switch deck. Centralab Type 2500, Number X
S2—Two pole, 5 position switch. Centralab PA-2003
L1—21 turns #22e space wound on 1" x ¾" form (National XR-72 with slug removed)
L2—8 turns of B&W 3104 Miniductor, 1" diam, 1" long. 808T. Air Dux 10 meter tap 2 turns up from C14. 15 meter tap 5 turns up from C 14. 20 meter tap at junction point of the two coils
L3—39 turns of B&W 3105 Miniductor, 1" diam, 2½" long. 40 meter tap 10½ turns from junction point of L2 and L3
PC—50 ohm, 1 watt composition resistor wound with 3 spaced turns #18 wire
P1—Cinch-Jones P2408-SB chassis plug and S2048-CCT cable socket

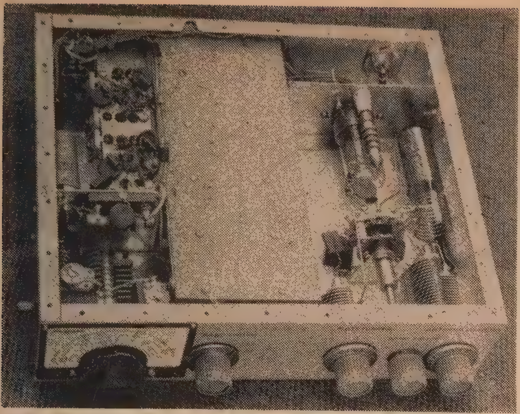


Fig. 92. Top view of VFO transmitter. The "Labgear" multiplier unit occupies the center of the chassis. The 2E26 stage is to the right of the multiplier, and the VFO to the left.

This unit is designed to operate in conjunction with the new dual voltage vibrator-type power supplies now on the market. The high overall efficiency of this type of supply assures that the greatest possible conversion efficiency from the automotive primary supply to the operating voltages is obtained.

Transmitter Circuit

The circuit of the 60 watt transmitter is shown in *Figure 98*. Seven tubes are employed in the transmitter: two in the r-f section, and five in the audio section. A 6AG7 pentode is employed in a modified Tritet oscillator circuit. When crystal control is used, the oscillator will deliver sufficient driving power to the p-a stage on 40, 20, 15 and 10 meters when a 7-Mc. crystal is employed. An 80 meter crystal is employed for 80 meter operation, and may be used for 40 meter operation, if desired. The cathode circuit of the 6AG7 stage employs a high-C circuit tuned to approximately 10.5-Mc. This tritet circuit permits harmonic operation of the oscillator, yet does not detract from fundamental "straight-through" operation. The plate circuit of the oscillator stage is bandswitched to the various amateur bands by means of *S1*. The grid drive to the amplifier stage is controlled by *R1*, the screen voltage potentiometer in the 6AG7 circuit.

A single 6146 is used as a class-C amplifier on all bands. The tube normally operates at a plate potential of 500 volts, and a plate current of 120 milliamperes, for an input of 60 watts. The plate circuit of this stage is a simple pi-network that will efficiently match the plate impedance of the tube to a low impedance coaxial line on all bands. A "tune-operate" switch (*S2*) is placed in the screen circuit of the 6146 tube to allow removal of the screen voltage during tuning periods. The plate circuit tuning condenser, *C2*, is a 140 $\mu\mu fd$. unit, which provides a correct *L/C* ratio on all bands except 80 meters. To maintain the correct ratio on this band, an auxiliary 100 $\mu\mu fd$. mica condenser is connected in parallel with the tuning condenser by the action of switch *S3*.

The transmitter is designed to be used with a single-button carbon microphone, such as the surplus *T-17* unit. The first section of a 12AX7 high-mu triode is used as a grounded grid audio amplifier stage. Microphone current is obtained from the cathode current of the tube, thus eliminating the need of a microphone battery and transformer. The second section of the 12AX7 is used as a resistance coupled voltage amplifier, with the gain control potentiometer, *R2*, in the grid circuit. The voltage amplifier is capacity coupled to a 6AL5 audio clipper. The actual level of clipping is controlled by the clipping potentiometer, *R3*, in the plate circuit of the 6AL5. Minimum clipping occurs when the arm of the potentiometer is at the high voltage end of *R3*.

To reduce the higher-order audio compo-

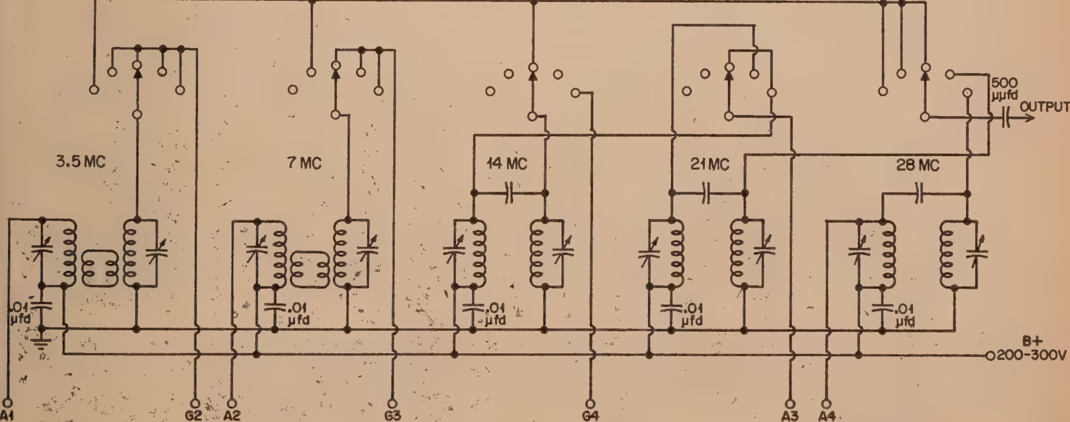


Fig. 93. Circuit of the Labgear wide-band multiplier.

nents created by clipping action, the output of the 6AL5 stage is passed through a low-pass audio filter that substantially eliminates all audio frequencies above 3500 cycles. The clipped and filtered speech wave passes next to a 12AU7 voltage-divider type phase inverter which delivers out-of-phase audio voltages to the grids of the two 6L6 class-AB modulators. These tubes are capable of 30 watts output of fully clipped audio power. Following the modulator stage is a second low-pass audio filter which removes the residual audio frequencies lying above 3500 cycles. It is immediately apparent that this clipping-filtering system is a decided advantage in mobile work when the transmitter is monitored in a nearby receiver. The modulation is heavy and full, yet the signal is sharp, having none of the sideband splatter commonly heard on mobile equipment.

Three circuits are measured in the transmitter: grid current of the 6146 amplifier stage, plate current of this stage, and plate current of the modulator. A single 15 milliampere d-c meter is used for the purpose. Direct reading of the meter is used for the grid current measurement, while the scale is multiplied by a factor of ten for each of the plate current measurements. Suitable shunts are incorporated in the positive voltage leads to the modulator and the p-a stage to provide a full-scale reading of 150 millamperes on the meter. A two pole, three position switch (*S5*) is used to switch the meter across the chosen circuit.

All power and control wires to the transmitter pass through a single power plug mounted on the back apron of the chassis. Each pin of this plug is bypassed to ground to insure minimum leakage of TVI-producing harmonics through the power wiring.

The Auxiliary VFO

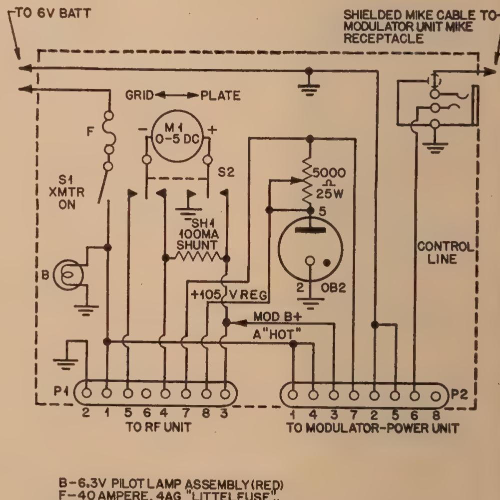
Provision is made to use an auxiliary VFO with the transmitter. A suitable unit is the *Johnson Mobile VFO*. This VFO may be purchased in kit form, and wired. A power plug is incorporated in the transmitter to supply plate and filament voltages to the VFO unit. The r-f output of the VFO is coupled to the input circuit of the 6AG7 oscillator tube by means of a short length of coaxial line. A double-pole double-throw slide switch converts the oscillator stage to a buffer stage, suitable for use with the external VFO. The *Johnson VFO* has a built-in voltage regulator, and since one is not required for crystal operation of the transmitter, no provision for voltage regulation has been incorporated in the transmitter.

Transmitter Construction

A good idea of the transmitter package assembly may be gained from inspection of *Figures 97, 99* and *100*. The transmitter is built upon an aluminum chassis measuring 7″x 11″x12″ (*Bud AC-407*). An aluminum enclosure made from a sheet of *Reynolds Metal Co. "Do it yourself"* perforated aluminum is formed around the top of the chassis. The overall height of the transmitter cabinet is seven inches. The enclosure overlaps the edge of the chassis one-half inch, providing an enclosure height of five inches above the chassis. The enclosure is formed from a sheet of perforated aluminum measuring 5½″x30″, and is bent to shape by clamping the sheet between blocks of wood, and forming the corners with a hammer. A one-half inch lip at each end of the enclosure is used to fasten the enclosure to the back of the front panel. The enclosure is firmly fastened every two inches around the edge of the chassis by means of #6 self-tapping sheet metal screws. The enclosure is held to the front panel by means of 4-40 machine screws.

A short length of ½″x½″ aluminum angle-stock is cut to length to form a brace around the inside edge at the top of the enclosure. A piece of perforated aluminum is cut to size to form the enclosure top, and is held in place with #6 self-tapping sheet metal screws. A second such sheet is employed to close the bottom of the chassis. A good TVI-proof enclosure is the result of this small amount of sheet metal work.

Placement of the major components above the chassis may be observed in *Figure 99*. The audio components are to the rear of the chassis, and the r-f components are grouped at the front. At the extreme rear are the modulation transformer, *T1*, and the two 6L6 modulator tubes. Next to the 6L6's is the low-pass filter, *LPF-2*, and the 12AU7 phase inverter tube. At the edge of the chassis are located the 6AL5 clipper tube and the 12AX7 speech amplifier. The audio gain control, *R2*,



B–6.3V PILOT LAMP ASSEMBLY (RED)
F–40 AMPERE, 4AG "LITTELFUSE"
S1–SPST HEAVY DUTY SWITCH C-H #7361
S2–DPDT TOGGLE SWITCH
M1–0-5MA, DC, TRIPLETT #227-PL
SH1–0.68 OHM, 1 WATT, 5% RESISTOR
P1, P2–CINCH-JONES S-2408-SB CHASSIS SOCKET AND P2408CCT CABLE PLUG.

Fig. 94. Schematic, Control Box.

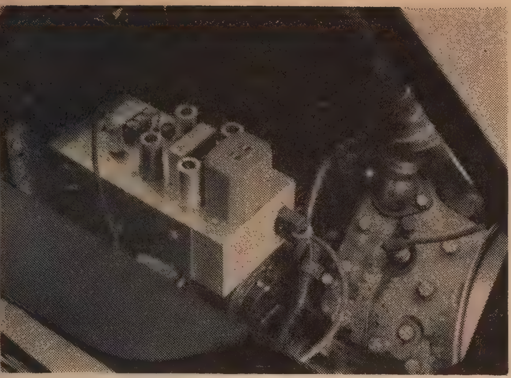


Fig. 95. The modulator-power supply unit is mounted to the radiator frame of the automobile, beneath the hood. The 300 volt, 150 ma. dynamotor is mounted upside-down beneath the modulator.

is located on the side of the chassis below the 12AX7 socket. The clipping level control, *R3*, is mounted on the chassis in front of the 12AU7 socket. This control is rarely adjusted, and in this case, a screw-driver type adjustment was employed.

To the front of the modulator stage is located the high level audio splatter choke, *CH1*. At the opposite side of the chassis the antenna change-over relay is placed.

Placement of the panel controls (*Figure 97*) dictates to a great extent the placement of parts directly behind the front panel. The antenna loading condenser (*C3*) is mounted to the chassis on one side of the O-15 ma. meter, and the meter selector switch (*S5*) is placed on the opposite side of the panel to balance the dial of *C3*. The plate tuning condenser (*C2*) is mounted to the front panel directly above *C3*, and is counterbalanced on the other side of the panel by the excitation control potentiometer, *R1*. The p-a bandswitch, *S3*, is mounted directly above the 2″ meter.

Below chassis, the oscillator tuning condenser, *C1*, is directly under the meter switch, in the corner of the chassis. It is mounted about 3″ behind the front panel, and driven by an extension shaft and a flexible coupling. The oscillator plate coil selector switch (*S1*) is beside *C1*, and is mounted about 4¼″ behind the front panel. It is driven by an extension shaft from the knob on the panel. The tube socket for the 6AG7 oscillator is mounted directly in front of *S1*, the shaft of *S1* passing directly over the socket. The socket for the 6146 tube is mounted to the side of *S1*, about 1″ from the edge of the chassis. The auxiliary antenna coupling condensers and their switch (*S4*) are placed directly below the antenna loading condenser, *C3*.

Along the left side of the chassis are placed the VFO power plug, the coaxial receptacle for the VFO output lead, the *"tune-transmit"* switch (*S2*), the crystal socket, and the *"VFO-crystal"* switch, *S1*. The right side of the chassis holds the audio volume control, *R2*, and the antenna coaxial receptacle. The power plug and the receptacle for the receiver antenna are mounted on the back lip of the chassis.

Transmitter Wiring

Reasonable care should be taken in wiring the transmitter, since a large amount of parts are to be placed in a relatively small area. All filament wiring should be done first, followed by the leads to the meter switch and the microphone jack. The meter shunts are mounted on a phenolic terminal strip just below the modulation transformer. Many of the resistors in the audio stages may be mounted between the pins of the tube sockets, or between the socket pins and nearby tie-point strips.

The small slung-tuned oscillator coils are grouped around the oscillator band switch, care being taken that the coils do not come too close to the splatter choke, *CH1*, mounted above the chassis. Sufficient clearance must be left above the chassis to permit screwdriver adjustment of the coil slugs.

The high frequency section of the 6146 plate coil is mounted by its leads directly to the back of *S3*. One end of the coil is attached to the stator lug of *C2*. The low frequency section of this coil is mounted in a vertical position, directly behind the excitation control potentiometer, *R1*. To hold it in place, a strip of lucite about ½″x½″x1″ is attached to the back of *R1* by means of *Duco cement*, and the coil is fastened to the strip by means of the cement. The 1250 volt mica padding condenser used for 80 meter operation is mounted above *R1*, as shown in *Figure 99*. All r-f wiring above the chassis is done with #16 tinned wire.

Testing the Transmitter

Before the transmitter is placed in the automobile, it should be bench tested with an a-c operated power supply. 300 volts at 50 milliamperes is required, as well as 500 volts at about 225 ma. The 6AG7 tube and the 6146 should be inserted in their sockets and low voltage applied to the transmitter. Various crystals should be tested, and the grid current to the 6146 measured on all bands. It should be 2 ma., minimum. Care must be taken to retard *R1* on the low frequency bands to keep the grid current of the 6146 below 4 ma., or damage to the tube might result. Both the 10 meter and the 15 meter bands are covered on the so-called "10 meter" position of *S1*. The 10 meter operating point is at minimum capacity of *C1*, and the 15 meter position near maximum capacity.

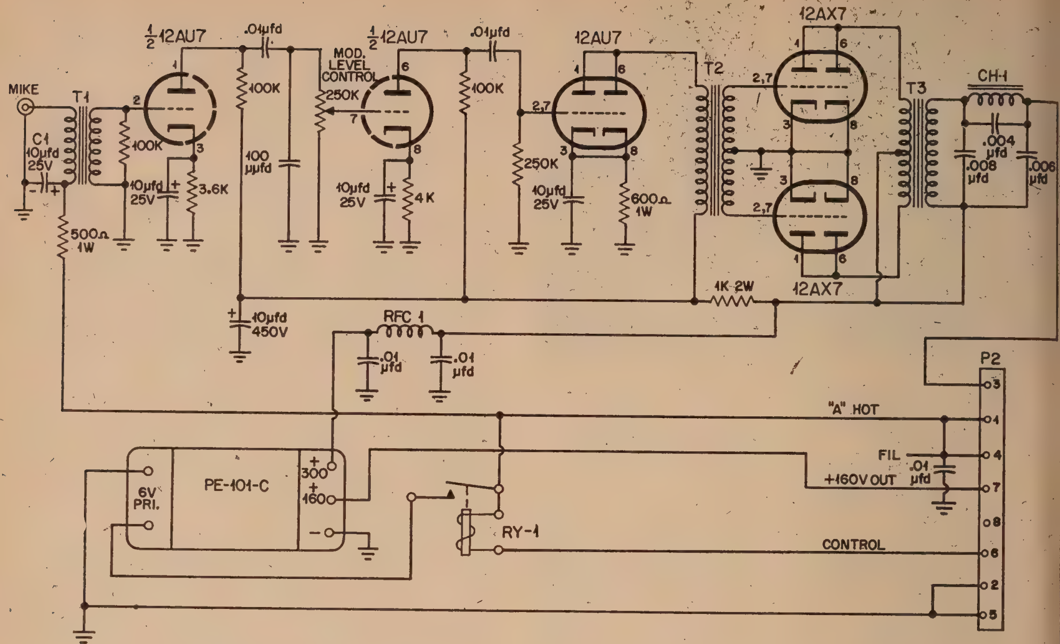


Fig. 96. Schematic of modulator power unit.

Parts List

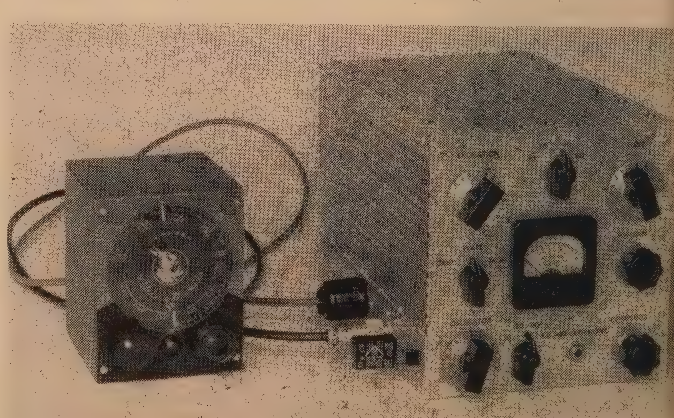
T1—Microphone Transformer. Stancor A-4705
T2—Driver Transformer. Merit A2922
T3—15 watt Modulation Transformer. UTCS-18 Primary impedance = 7000 ohms. Secondary impedance = 4000 ohms
CH1 — Triad Splatter choke C-26X
C1—10 uf, 25 volt electrolytic. If positive of auto battery is grounded, reverse polarity of this condenser
RY-1—Horn relay
P2—Cinch - Jones S2408-SB chassis socket and P2408-CCT cable plug
Note—Ground dynamotor primary circuit directly at P-2 to reduce primary circuit voltage drop

The slugs of the 20, 40 and 80 meter oscillator coils should be adjusted so that oscillator resonance occurs with *C1* about one-half capacity.

A suitable antenna load should be connected to the transmitter and high voltage applied to the unit. Until *S2* is closed, the p-a stage remains inoperative. For 80 meter operation switch *S4* should add maximum loading capacity to the circuit, and should remove all extra capacity for 10 meter operation. At resonance, plate current of the 6146 stage should drop to 20 ma. or less. Under conditions of correct loading, the plate current of the 6146 may be as high as 140 ma.

After the r-f section of the transmitter is operating properly, the audio tubes may be inserted in their sockets. Resting plate current of the modulator stage should be about 80 ma. As a starter, the clipping control, *R3*, should

Fig. 97. 60 watt all-band mobile transmitter. Designed for use with an external VFO, this transmitter incorporates speech clipping and audio filtering. Operating on the 10, 15, 20, 40 and 80 meter bands, this transmitter is an ideal unit for the serious "mobileer." It may be used with a home-built or commercial VFO.



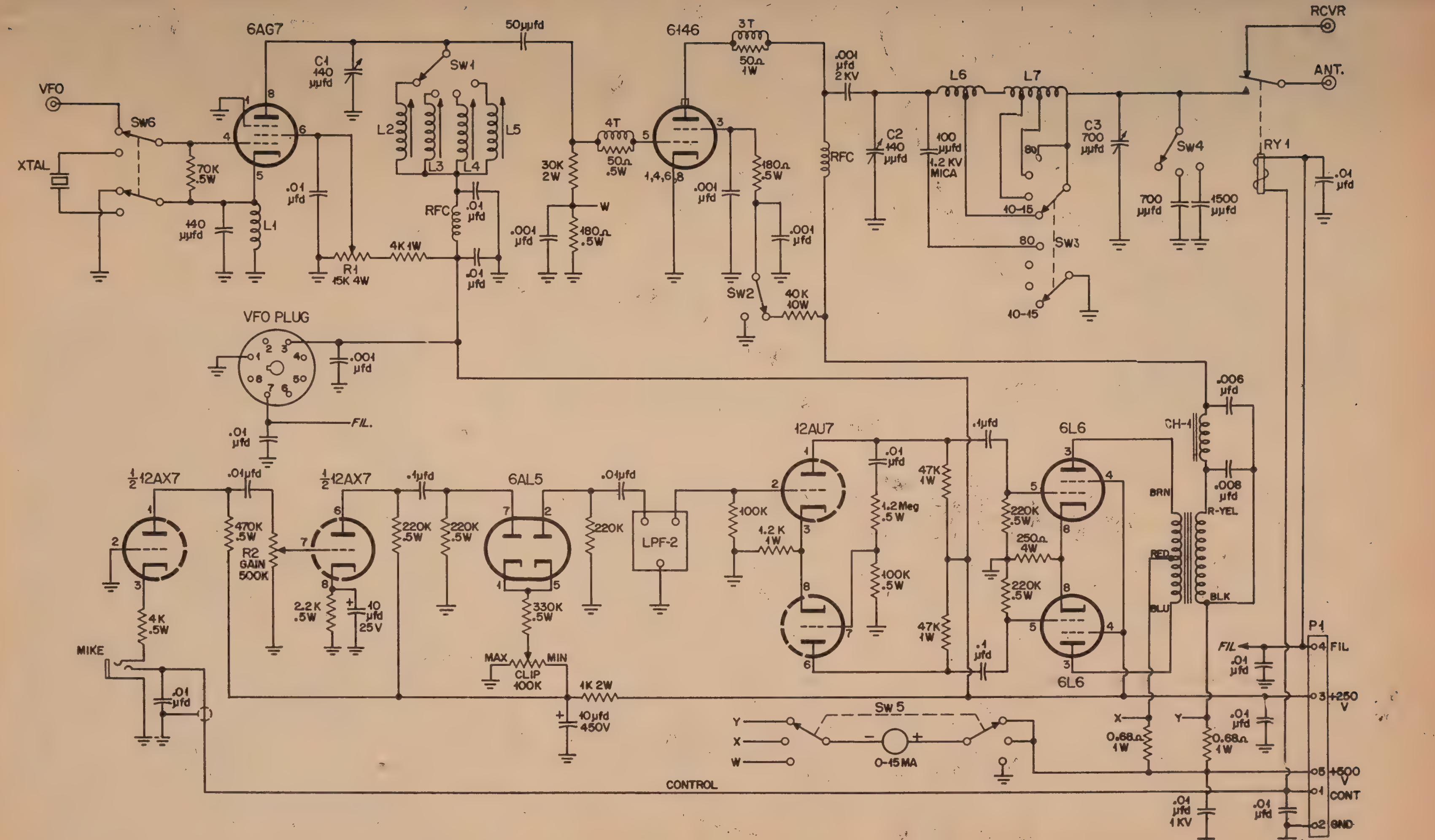


Fig. 98. Schematic, 60 Watt transmitter. (Corrections: increase voltage from 250 to 300 on terminal #3; subsitute 6H6 for 6AL5 and connect pins 3 & 5 together to 330K resistor, pin 4 to the .1 μfd input condenser and pin 8 to the .01 μfd output condenser.) See parts list on page 172.

Parts List

All bypass condensers centralab type DD or equivalent

C1—50 uufd. Bud MC-1856

C2—$\mu\mu$fd Bud MC1856

C3—Two section b-c type, 350-350 uufd.

L1—8 turns #20, 1" diam, ½" long (2.4 uh) B&W 3015 or Air Dux 816T

L2—(10-15 meters) 8 turns, 1½" diam. 1" long #14e. Resonate to 29.7 mc with C1 90% open

L3—(20 meters) 23 turns #28e, ¼" diam, ⅜" long (3 uh) J. W. Miller Co. #4504 with powdered iron slug

L4—(40 meters) 38 turns #32e, ¼" diam, ⅜" long (9 uh) J. W. Miller Co. # 4506 with powdered iron slug

L5—(80 meters) 45 uh. J. W. Miller Co. #4509 with powdered iron slug

L6—(10-15 meters) 8 turns #14e, 1" diam, 2" long Air-dux #804T. (Ten-Fifteen meter tap at 6½ turns)

L7—(20-80 meters) 26 turns #18e, 1" diam, 1½" long Air-dux #816T. 20 meter tap at 6 turns, 40 meter tap at 17 turns

R1—15,000 ohms, 4 watt potentiometer

S1—Single pole, 4 position ceramic switch

S4—Two pole, 4 position ceramic switch

LPF-2—Low Pass Filter. Chicago Transformer Co. LPF-2

T1—Universal Modulation Transformer. 40 watt Triad M3X

CH1—100 ma. splatter choke. Triad C-26X

P1—Jones Plug, 5 contact, 20 ampere

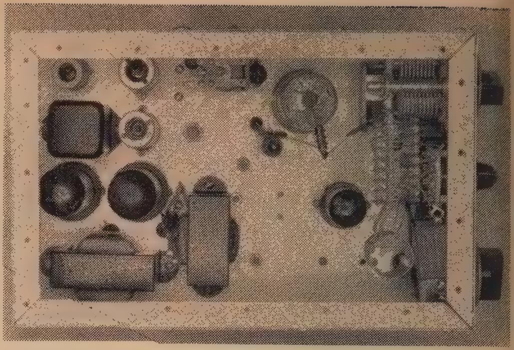


Fig. 99. Top view of the 60 watt transmitter the audio section is to the left (rear of transmitter) and the h-f section to the right. 6146 plate coils are mounted to the rear of the p-a plate switch. The same coil section serves for both 10 and 15 meter operation. The antenna relay is just behind the 6146 tube.

be set with the arm at the high voltage end of the potentiometer. This results in no clipping. Audio excitation should be applied to the modulator, and the audio level control advanced until the modulator plate current kicks to 120 ma. or so. The clipping control may now be advanced until it is at about ½ scale. Too much clipping will make the voice sound rough and boomy. When the correct clipping level is found, the audio level may be advanced a bit until a point of overmodulation is found. Just before this point, the audio system will be at a point of maximum effectivity.

Car Installation

The transmitter is designed to operate from a dual voltage supply providing 300 and 500 volts. If desired, a PE-103A dynamotor may be used for the high voltage supply, and a 300 volt, 100 ma. vibrator supply for the low voltage power unit. Filament connections for both six and twelve volt operation of the transmitter are given in *Figure 101.*

Mobile TVI

A great many amateurs are turning to mobile operation as an "out" to TVI. They assume that the low powered mobile transmitters will not cause TVI, or if they do, that it will not last for long on any particular TV set, as the car is in motion. Both of these assumptions are apt to be incorrect. The strength of the transmitter harmonics have little to do with the power input to the transmitter. Instances have been brought to light where a 20 watt mobile transmitter blocked Channel 2 for a radius of 4 miles from the car.

The problem of Mobile TVI is not so bad on the low frequency bands of 80 and 40 meters, since the harmonics from these bands are of a higher order than are those of a 10 meter transmitter. Even so, certain precautions must be taken on these bands to prevent excessive harmonic generation and radiation. The following points must be taken into account regardless of the operating frequency or power of the transmitter:

1—Correct circuit design to minimize harmonic generation.

2—Suppression of generated harmonics.

3—Filtering and shielding to confine generated harmonics.

Let us examine each one of these points in turn, and see how they enter into the mobile field.

Correct Circuit Design to Minimize Harmonic Generation

The *choice* of circuit and the *way* it is assembled and wired will have a definite bearing upon the harmonic content of the transmitter.

1. The modulated amplifier should operate "straight through," and never as a frequency multiplier. A modulated doubler stage will radiate appreciable energy upon the sub-harmonic and the third harmonic, in addition to having greatly enhanced higher harmonics.

2. The modulated amplifier should operate with a relatively high-C tank circuit. A single ended pentode stage requires a great deal higher C/L ratio than a push-pull stage of the same power input. Evidence of too low a C/L ratio often shows up in a pentode stage by erratic tuning—maximum output and minimum plate current dip not coinciding on the

tuning condenser.

3. If possible, the modulated stage should not be driven by a doubler. This is a redundant statement, since this is the universal practice. It is not the best scheme, however, from a TVI point of view. If this practice is followed, care must be taken to suppress the generated harmonics before they can cause damage.

4. The transmitter should be tested for instability and parasitics. Many times a parasitic will lie quiescent until the plate voltage reaches a high level on a modulation peak, then it will break forth, generating a whole string of harmonics. A quick check for parasitics may be made by removing the crystal from the transmitter and turning it on. If grid current flows in the final stage under this condition, it is a sure sign that the final stage has a parasitic in it. This test should be done rapidly to prevent the transmitting tubes from being harmed by the temporary overload. The reader is referred to the various Amateur Handbooks for a discussion of parasitic elimination.

Suppression of Generated Harmonics

1. By careful assembly, the generated harmonics may be attenuated and suppressed. All power leads should be bypassed *at the tube end and also at the power receptacle end of the wire*. Small, ceramic, "oystershell" condensers make excellent bypasses for such leads. The condenser leads should be kept as short as possible for most effective bypassing. Paper and mica condensers should be avoided wherever possible in r-f circuits.

2. If space allows, all power leads and filament leads should be made out of shielded wire. The shield at each end of the lead should be grounded to the chassis. This is sometimes a difficult thing to do in a compact mobile installation. However, it is a "must" if much 10 meter operation is contemplated.

3. All leads leaving the transmitter should be filtered. At the minimum, this means a .001 *μμfd.* ceramic "oystershell," such as the *Erie* 801-001 on each lead. For high voltage leads carrying over 400 volts, the *Erie type 1R5KV* high voltage disc Ceramicon is recommended. This condenser is made in 1500, 3000 and 6000 volt ratings.

Condensers such as these, mounted directly between ground and the prongs of the power plug will effectively "cool off" the power wiring to a great degree. In extreme cases, a small VHF r.f. choke, such as the *Ohmite Z-50* must be put in series with the power leads just after the bypass condensers.

Filtering and Shielding to Confine Generated Harmonics

1. The transmitter must be shielded. A nice, new, shiny cabinet is no guarantee of good shielding. All cabinet seams that are spot welded should be cleaned and soldered shut. The panel should make a good electrical connection to the cabinet, and should be bolted to the cabinet every two inches or so. Ventilation louvres should be screened on the inside to prevent stray radiation thru the slots.

2. The r.f. output circuit of the transmitter should leave the enclosure of the transmitter via a shielded coaxial plug. In this way a coax line filter may be employed without the danger of the harmonics dodging the filter by running up the outside of the coaxial line.

3. If the antenna relay is not incorporated into the transmitter, it should be mounted in a closed box, with a coaxial fitting on one side. A coax line may run from this fitting to the r.f. coax fitting of the transmitter. The 6 volt line to operate the relay should be bypassed as it enters the relay box, and, if possible, the line should be shielded. The box may be mounted at the base of the whip inside the car to keep

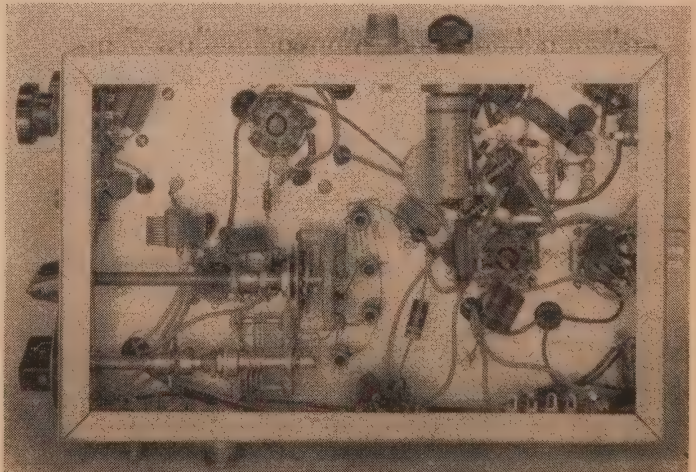


Fig. 100. Under chassis view of transmitter. The oscillator coils are at center behind the oscillator bandswitch, S1. Tritet coil for the 6AG6 is directly beside the tube socket. Audio components are grouped at rear of chassis.

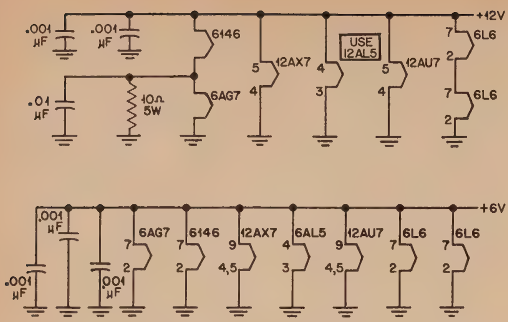


Fig. 101. Filament connections, 6 & 12 volts.

the lead from the relay to the antenna to a minimum.

Antenna Filters

After the transmitter has been cleaned up, it is time to think about antenna filters. The usual mobile installation uses a tuned antenna fed with a short length of 50 or 70 ohm coaxial line. Since it is a rare whip that provides a 50 or 70 ohm termination for a coaxial line, the usual mobile installation must either put up with a SWR (standing wave ratio) of 2 or 3 to 1, or use some sort of matching device between the line and the antenna. At the power levels encountered in mobile work, a standing wave ratio of this magnitude is not serious, and the filters to be described will perform in a satisfactory manner.

A Parallel Tuned Filter

This low pass filter is designed for use in a 50 ohm line. *Figure 102*. It is a pi section filter, with three tuned networks. Network *A* is tuned to channel 2 (58 Mc.), Network *B* is tuned to Channel 4 (71 Mc.), and Network *C* is tuned to Channel 2 video (54 Mc.). Higher channel attenuation is achieved by the parallel condensers to ground.

The filter may be installed as a separate unit or it may be built directly into the transmitter between the coax relay and the antenna outlet receptacle. In either case, the addition of the filter may introduce some reactance into the circuit which is easily compensated for by retuning the final amplifier. If a *pi* network is used, the loading condenser will have to be increased in value. If it is not big enough, a small ceramic or mica padder should be shunted across it.

Construction

The unit may be built in a small dural box, with the coax fittings on each end. The parallel tuned circuits may be made by winding No. 20 enameled wire directly upon the NPO ceramic condensers. Solder one end of a few feet of No. 20 enameled wire to the ceramicon pigtail and wind the coil according to *Figure 102*. Solder the other end temporarily to the other lead of the condenser and grid-dip the circuit. Spread or squeeze the turns of the coil until the resonant frequency is approximately correct. When the three tank circuits are completed, solder them in series and attach the 93 $\mu\mu fd$. condensers.

When assembling the complete low-pass filter, it is necessary to keep each tank circuit at right angles to its neighbor to reduce coupling.

This filter has a cut-off frequency of about 36 Mc. This means that harmonics of 10 and 20 meters are substantially attenuated. There is no noticeable attenuation of the fundamental frequency of the transmitter.

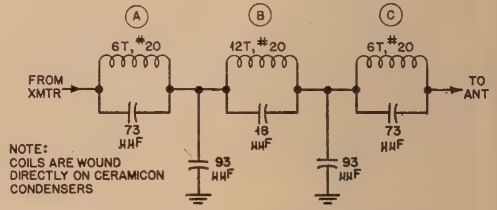


Fig. 102. Simple mobile TVI filter.

Chapter Six

Mobile Single-Sideband Equipment


SQUAWK!
QUACK!
QUACK!
BANDEL LINN

Mobile Single-sideband Equipment

An amplitude modulated signal—like Caesar's Gaul—is divided into three parts: the carrier and the upper and lower sidebands. A representation of such a signal is shown in *Figure 1*. This signal is an idealized phone signal. Only the necessary speech frequencies are transmitted. By the use of a low-pass filter in the speech equipment, the frequencies above 3000 cycles have been eliminated, and by proper choice of coupling condensers the low audio frequencies below 300 cycles are attenuated. The r-f envelope for a typical amplitude modulated signal is shown in *Figure 2*. In a typical case of a 100-watt phone transmitter, the carrier has a power of 100 watts, while each sideband contains 25 watts of power. Since the intelligence of the signal is transmitted in the sidebands, and since it is entirely possible to obtain all of the wanted intelligence by listening to only one sideband, it is apparent that a 100-watt a-m transmitter must waste a lot of power to generate a sideband of 25 watts. In mobile work where every watt of power must be supplied by the automotive system of the car, the overall low efficiency of an amplitude modulation system is a major drawback.

If it is possible to eliminate the carrier and one sideband, the same peak power may be placed in the remaining sideband, providing a worthwhile increase in radiated power for the same amount of primary power drawn from the automotive electrical system.

SSB Generators

There are two methods of generating a single-sideband signal. The older method in use for many years is the *filter method*. The other system which has become popular in the last few years is the *phasing method*. Each has its own merits and careful design will produce a satisfactory signal with either system.

A block diagram of a filter-type SSB transmitter is shown in *Figure 3*. The SSB signal is generated at some low frequency and then hetrodyned by means of mixer stages to the desired operating frequency. In this particular example, the r-f signal is generated at 450 kc and combined with the audio signal in a mixer, or modulator stage. By proper design, the original carrier may be partially suppressed in the mixer stage, and the output of this circuit will consist of a double sideband signal, with a suppressed carrier. The signal is now run through a fixed-tuned filter which removes the remainder of the carrier and one of the sidebands. A single-sideband, suppressed carrier (SSB) signal is obtained at the output of the

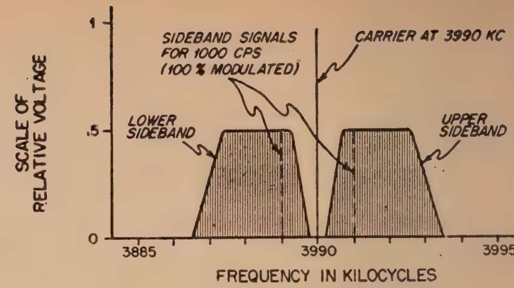


Fig. 1. Relative amplitude-versus-frequency representation of a double-sideband AM signal. Note the equal distribution of energy (hence intelligence) into two sidebands.

filter. This signal may be mixed (or hetrodyned) to the chosen operating frequency, and then amplified at this frequency.

Since the actual SSB signal is generated at a low level, it is necessary to use amplifiers that will faithfully reproduce the signal as originally generated. Such an amplifier is termed a *linear amplifier*.

A block diagram of a phasing-type SSB transmitter is shown in *Figure 4*. It is not necessary for the phasing-type transmitter to work at a low frequency as in the case of the filter-type exciter. In most cases, the phasing transmitter generates the SSB signal directly at the frequency of operation. The heart of the phasing transmitter is the audio phase-shift network. This is a special circuit that will take a restricted range of audio frequencies and split it into two channels, maintaining a 90 degree phase difference between the two channels. The r-f signal is also fed into a phase splitting network to obtain two r-f signals having a 90 degree phase difference between them. When the audio signals and r-f signals are combined in the proper manner in diode modulator stages, two double-sideband suppressed carrier signals are formed. These two signals are then combined, resulting in a cancellation of one set of sidebands. The resulting emission is a single-sideband, suppressed carrier signal.

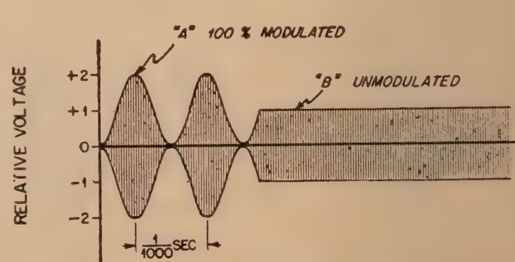


Fig. 2. This is the common r-f envelope pattern of a double-sideband AM signal with 100% modulation (1000 cycle tone) at the left. The envelope appearance in an unmodulated condition is shown at the right.

Examples of each type of SSB transmitter will be given in this Handbook. For a complete discussion of SSB theory, design and practice, the reader is referred to *Single Sideband Techniques,* by Jack N. Brown, W3SHY, published by Cowan Publishing Corp., 67 West 44th St., New York 36, N.Y.

a Mobile Phasing Transmitter

Described herewith is a simple phasing-type SSB transmitter designed for mobile work capable of raising the level of your signal at the distant station by 9 DB (approximately equivalent to jacking up your 50-Watt signal to a hefty 400 Watts). This is accomplished with *NO* increase in primary battery power consumption. The slight additional filament drain because of the larger number of tubes is much more than offset by the *ZERO* plate supply demand of the final during speech pauses and between syllables.

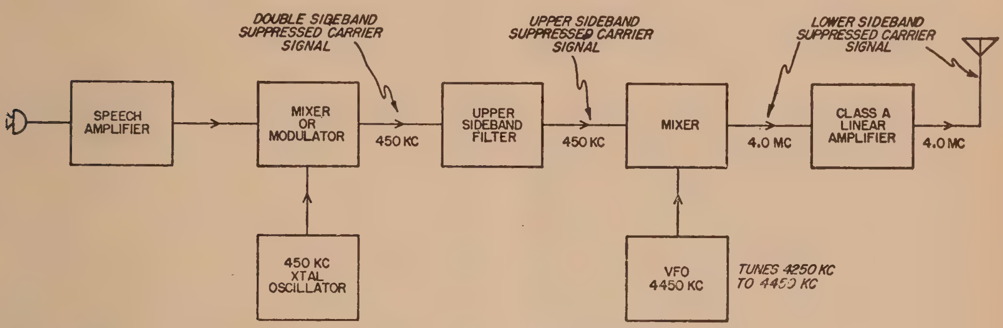


Fig. 3. Block diagram of a simple crystal-filter type SSB exciter.

The exciter portion is patterned after the exceedingly popular 10A unit, marketed by *Central Electronics Incorporated* of Chicago, Illinois. This not only has the virtue of using a circuit that is time-tried and completely "de-bugged" but also simplifies the procurement of certain components, from the manufacturer of the 10A, which might otherwise be difficult to obtain. Being able to purchase ready-made the phase-shift network eliminates a time-consuming and laborious task requiring several items of precision test equipment not available in every ham workshop.

Without delving too deeply into "sideband" theory, which has been well covered elsewhere, the functioning of the transmitter stages is as follows: One half of a 12AX7 low-noise twin triode tube is employed as a dynamic microphone pre-amplifier stage with the second section providing additional amplification. It should be possible to substitute a crystal microphone without circuit alterations. The speech gain control is interposed between the second stage and the control grid of one half of a 12BH7 used to furnish a small amount of audio power which is needed to drive the balanced input of the phase shift network through the coupling transformer, *T1*.

The audio phase shift network, by means of several series and parallel pairs of R-C circuits, develops two output signals, amplified separately by the two triodes of a 12AT7, which are identical in amplitude but which maintain very close to a 90° phase relationship throughout the voice-frequency range.

These two audio signals, still maintaining their quadrature relationship, appear at the secondaries of *T2* and *T3*. That from *T2* is applied to a balanced modulator, consisting of a pair of matched germanium crystals, at the same time that a 9 mc. radio frequency voltage is applied to the same modulator. By the mechanics of modulation this produces a double sideband RF signal from which the 9 mc. carrier frequency has been removed by cancellation in the primary circuit of *L3*. Slight differences in the two crystals of the modulator are corrected through the carrier balancing control, *R23*.

In identical fashion the other audio signal, from the secondary of *T3*, is applied to a second balanced modulator along with a 9 mc. signal from the same crystal oscillator. This r-f voltage must have a 90° phase relationship with that applied to the first modulator and phase shift is very easily accomplished making use of the principle whereby two resonant circuits, less than critically coupled, and detuned in opposite directions to the half-power points where the resistance and reactance are of equal magnitude, will have a quadrature phase relation.

Combining at the primary coil of *L3* we have two double sideband, carrier suppressed currents. Because of the vectorial relationships of the pairs of double sidebands, in one position of the switch *S1* the two upper sideband voltages will cancel out while the two lower sideband voltages will add to double amplitude.

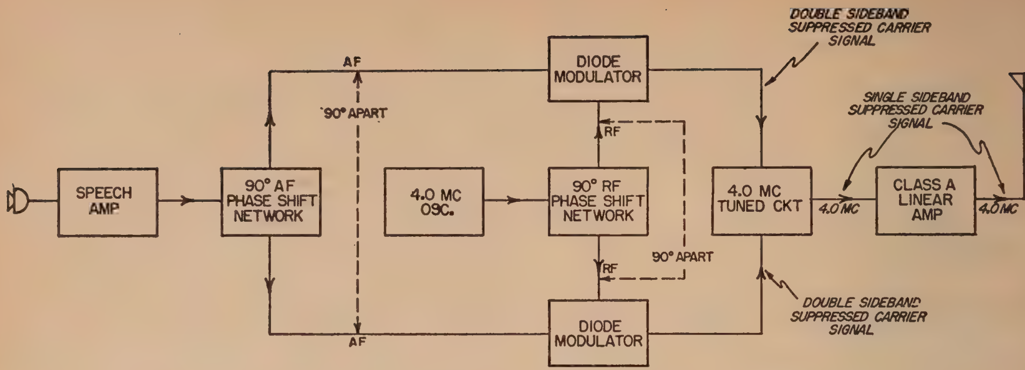


Fig. 4. This is a block diagram of the "SSB, Jr." It is a fundamental-frequency type of phasing exciter. Full details are in the Nov.-Dec., 1950 issue of the "G.E. Ham News."

Reversing the phase of the voltage from *T2* in the next switch position will cancel the lower sideband and pass the upper.

After passing through *L4* and *L5,* whose purpose is the provision of additional discrimination against unwanted products of modulation, the lone sideband that remains is applied to the signal grid of the 6BA7 mixer stage. The oscillator portion of the mixer tube is wired as either a Pierce crystal oscillator or to accept the 8-volt output of a VFO operating in the vicinity of 5 mc. As a result of mixing action a number of frequencies are simultaneously present in the 6BA7 plate circuit but the only two holding interest for us are in the 75 and 20 meter bands. All of the undesired frequencies are eliminated by the selectivity of the following tuned circuits and the 15 mc trap.

The 6AG7 stage furnishes drive for the final and is operated as a strictly class A amplifier in order that no distortion be introduced into the sideband signal. Since class A r-f amplifiers have extremely high power sensitivity stability would be a problem were it not for the tuned-circuit loading resistors *R34* and *R35* which serve the twofold purpose of stabilizing the 6AG7 and improving the regulation of the r-f voltage fed to the control grid of the 807 linear amplifier.

A large selection of tubes is available for use as a final amplifier but, at the supply voltages common to most amateur mobile installations, there seems little to choose between them. The old favorite 807 is very satisfactory and has required no special treatment other than the inclusion of the customary parasitic suppressors.

The output circuit of the 807 stage uses a pi-network for ease of matching the mobile antenna. The band selector switches *S3, S4* and *S5* are ganged for single control operation. Coils have been installed for the 75 and 20 meter bands, but switch positions are available for three additional bands.

The wiring is so arranged that the transmitter may be operated from an external a-c power supply and used as a fixed station, or as an exciter for a high power linear amplifier. An extra position on *S1* permits the transmitter to generate a phase-modulated signal for NBFM operation by removal of the audio voltage from *T1* and a slight unbalancing of *R24*.

The transmitter is enclosed in a cabinet designed for under-dash mounting. Cabinet dimensions are: 11¼″ wide, 7″ high and 8½″ deep. Most of the parts and their placement are visible in the photographs since, unlike some mobile equipment, the parts are not stacked in inaccessible layers.

The second resonant coil of the r-f phase-shifting network (*L2* of *Figure 7*) secures its voltage by induction, hence the one-wire connection. By mounting the coil a short distance from *L1, L2* picks up sufficient r-f voltage to properly operate its modulator. It is not critical in placement so long as one remembers that the r-f voltage should be several times larger than the audio voltage from *T3*.

The various power supply potentials are brought in through a Jones plug on the rear of the chassis. Filament connections are arranged so that a choice of either 6 or 12 volt operation is had. All tubes, with the exception of the 807, receive their plate supply from the receiver vibrator supply. This leaves the PE 103 dynamotor to run just the final. During speech the voice peaks cause the 807 plate current, as indicated on the panel milliameter, to kick up to 100 mils. At the same time the dynamotor output voltage varies between 500 and 585 volts.

Tuning information for a phasing transmitter of this type is covered in the afore-mentioned book *Single Sideband Techniques* by Jack Brown.

a Filter-type SSB Transmitter made from a BC-453 "Command" Receiver

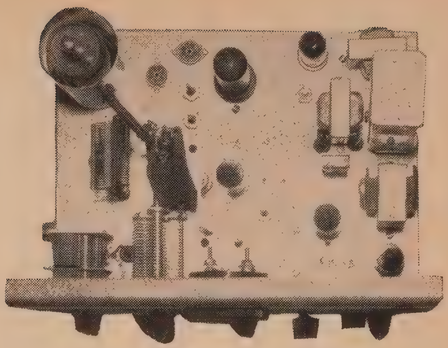


Fig. 6. Top view of mobile SSB transmitter. The r-f output stage is to the left, audio stages to the right.

A simple mobile SSB transmitter may be made from a converted BC-453 (190-550 kc) surplus "Q-5'er" receiver. Shown in this section is a transmitter of this type designed and built by "Buddy" Alvernaz, W6DMN, electronic engineer of *Jennings Radio Mfg. Co.*, San Jose, Calif. The SSB unit provides a 3-watt peak power SSB phone signal at any frequency in the 80 meter phone band. The complete transmitter may be powered by a 300 volt, 100 milliampere vibrator power supply.

The Circuit

The transmitter to be described is of the "filter" type, using cascaded 85 kc transformers of the BC-453 receiver to obtain a low frequency passband suitable for carrier and sideband rejection. For simplicity, the transmitter is built directly upon the chassis of the "Q-5'er", since many of the original components, and a part of the original circuit wiring may be employed in the SSB unit.

A block diagram of the transmitter is shown in *Figure 13.* 9 tubes are employed. Six of these tubes mount in the tube sockets that are already in the chassis of the BC-453, and the extra three tubes are mounted in the unused dynamotor well of the receiver. Reference should be made to the circuit diagram of the BC-453 "Command" receiver, shown in Chapter 3 of this Handbook. A comparison between that circuit and the circuit of the SSB transmitter of *Figure 14* will show the striking similarity between the two units, and explain the unusual fact that a receiver may be modified into a single-sideband transmitter!

A single 12AT7 is employed as a two stage audio amplifier. This tube is mounted in the unused dynamotor area of the chassis. Following this stage is the audio level control, *R1*, and a 6J5 phase inverter. The 6J5 tube is mounted in the 2nd i-f tube socket *(V-6,*

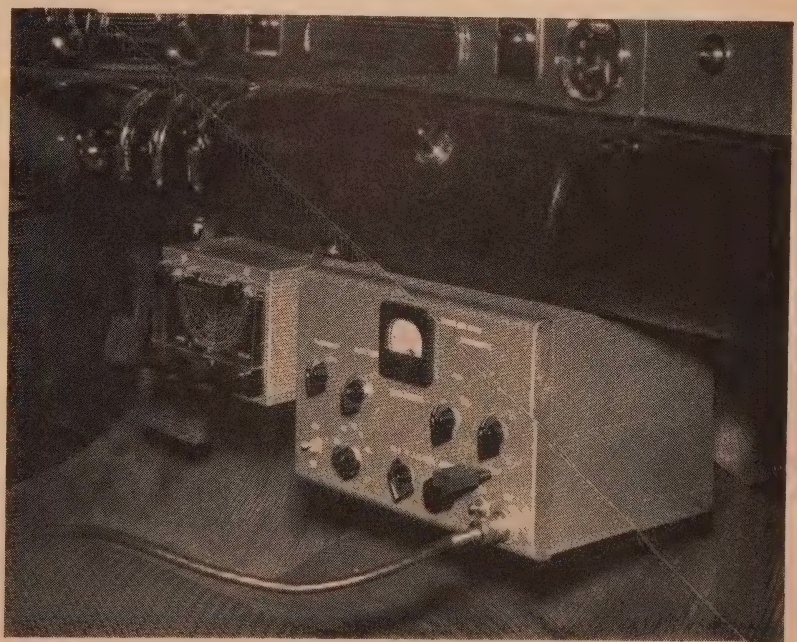


Fig. 5. The advantages of SSB transmission apply equally to mobile work or fixed station operation. This phasing type transmitter is designed for efficient operation on the 75, 40, 20, 15 and 10 meter bands and provides greatly increased "talk power" for a minimum of primary power drain.

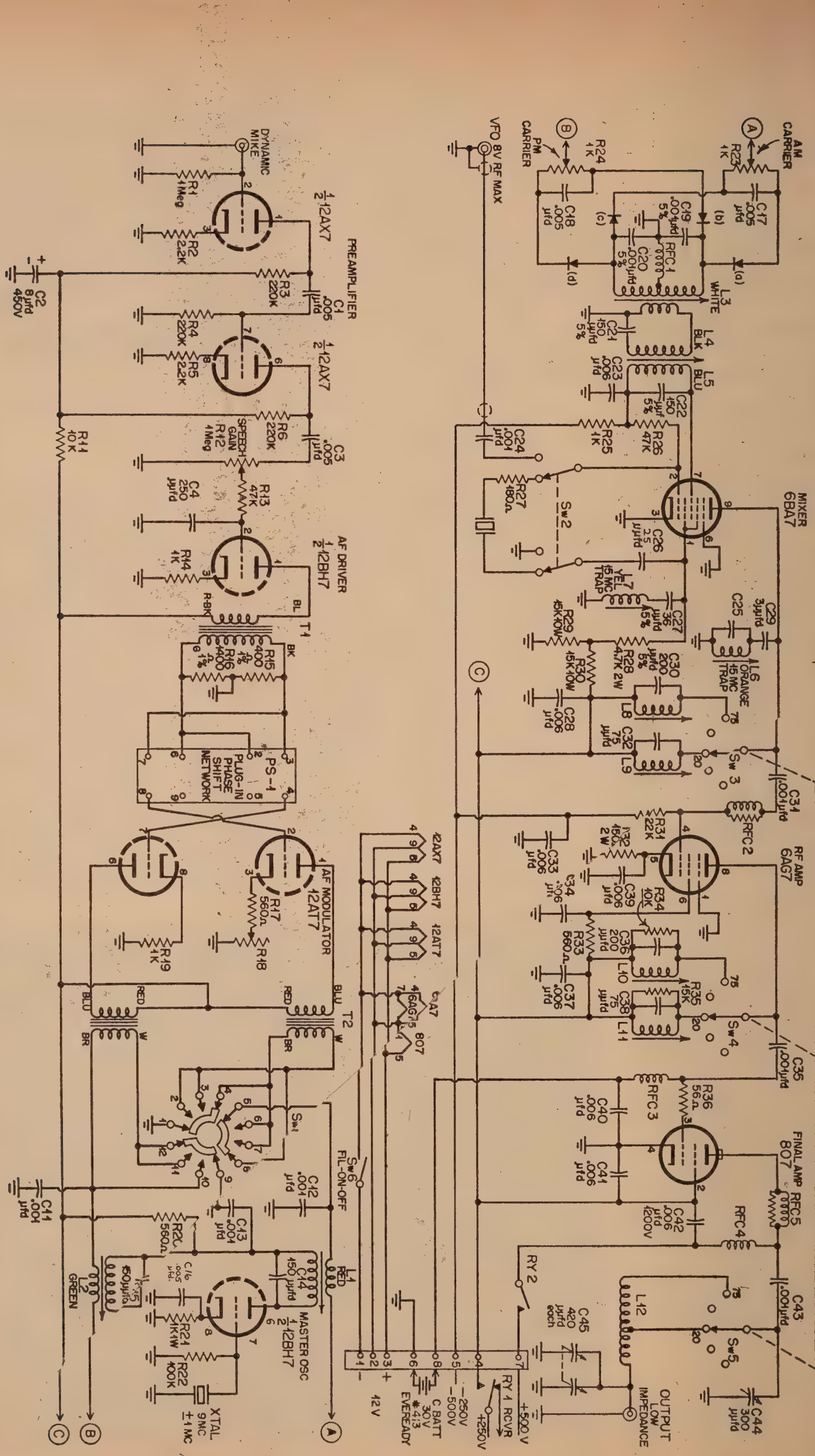


Fig. 7. Complete schematic for the SSB mobile transmitter.

Coil Winding Data, Fig. 7.

L1 through L7—pre-wound, Central Electronics
L8, L10—National XR50 forms, 32t. closewound #28 enamel
L9, L11—National XR50 forms, 17t. closewound #20 enamel
L12—B & W Miniductor, 1" dia., 40t. 1¾" long with tap at 6th turn for 20 meters

12SK7). The balanced, out-of-phase audio voltages from the 6J5 are coupled into the cathode circuit of a 6SN7 balanced modulator tube, which is mounted in the 12SR7 second detector (*V-7*) socket.

The b-f-o coil of the receiver (*L12-L13*, part #5852) is used as the low frequency conversion oscillator of the SSB transmitter. A 6SN7 tube is employed as the oscillator and a r-f phase inverter. It is mounted in the 12A6 audio amplifier (*V-8*) tube socket of the receiver. Two 85 kc i-f transformers are loosely coupled together to form the input section of the SSB filter. The last i-f transformer of the receiver (*L10-L11*, part #4677) is now used as the input transformer, and the middle i-f transformer of the receiver (*L8-L9*, part #7267) is used as the center section of the filter. The output of *L8-L9* feeds the new 85 kc band-pass amplifier tube, a 6SK7. This tube is mounted in the old first i-f amplifier tube socket, *V-5*.

The output of the 6SK7 tube is fed to the output section of the SSB filter, which is composed of the first i-f transformer of the BC-453 (*L6-L7*, part #4698). This transformer is connected to the variable i-f oscillator, a 6K8 tube which is mounted in the old 12K8 mixer socket (*V-4*). The oscillator section of this stage tunes from 275-635 kc, using the old receiver oscillator coil, *L4-L5* (part of assembly #5852). The frequency of this oscillator is set by the main tuning dial of the receiver. The r-f output of this mixer stage falls in the 190-550 kc region, depending upon the frequency of the 6K8 conversion oscillator. The old 12SK7 r-f stage of the receiver (*V-3*) is now converted to a 6SK7 variable frequency i-f amplifier, using the mixer grid coils (*L2-L3*, part of assembly 5852) as the input circuit, and the old r-f coil, *L1* (also part of assembly 5852) as the output circuit. At this

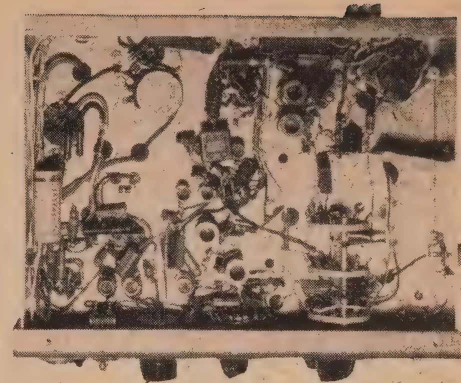


Fig. 8. Under-chassis placement of parts within the mobile SSB transmitter.

Parts List (Fig. 7)
All Resistors ½ Watt Unless Otherwise Specified

R1—1.0 megohm.
R2, R5—2200 ohms.
R3, R4, R6—220,000 ohms.
R11, R34—10,000 ohms.
R12—1.0 megohms with taper.
R13, R26—47,000 ohms.
R14, R19, R25 — 1000 ohms.
R15—400 ohms, 1% tol.
R16—1400 ohms, 1% tol.
R17, R20, R33—560 ohms.
R21—1000 ohms, 1w.
R22—100,000 ohms.
R23, R24 — 1000 ohms linear pot.
R27—180 ohms.
R28—4700 ohms, 2w.
R29, R30—15,000 ohms, 10w.
R31—22,000 ohms.
R32—150 ohms, 2w.
R35—15,000 ohms.
R36—56 ohms.
C1, C3—0.005 μfd. paper, 400v.
C2—8μfd. @ 450 electrolytic.
C4—250 μfd. mica, 500v.
C11, C12, C13, C24—0.001 μfd. mica, 500v.
C14, C15, C21, C22—150 μfd., 5% tol. 500v. mica.
C16, C17, C18—0.005 μfd. mica, 500v.
C19, C20—0.001 μfd. mica, 5% tol.
C23, C26, C28, C33, C34, C37, C39, C40, C41—0.006 μfd. mica, 500v.
C25—25 μμfd. mica, 500v.
C27—36 μμfd. mica, 5% tol. 500v.
C29—3 μμfd. ceramic, 500v.
C31, C32 — 0.001 μfd. mica.
C30, C36—200 μμfd. 5% mica, 500v.
C32, C38—75 μμfd. mica, 5%, 500v.
C42—0.006 μfd. mica, 1200v.
C44—300 μμfd. variable.
C45—420 μμfd. per sect. TRF type 2 sections.
Sw1—Modulation selector, Central Electronics.
Sw2—d.p.d.t. Toggle.
Sw6—s.p.s.t. Toggle.
Sw3, Sw4, Sw5—Ganged Mallory Type 181C.
T1—Driver transf., special, Central Electronics.
T2, T3—Mod. transf., special, Central Electronics.
PS1—Phase shift network, special, Central Electronics.
(a) (b) (c) (d)—1N48 crystal diodes; matched set, Central Electronics
RFC1—0.5 Mh.
RFC2—6 turns on 56-ohm, 1w. resistor.
RFC3—1 Mh. r-f choke
RFC4—2.5 Mh. r-f choke.
RFC5—5 turns on 50 ohm, 2w resistor.

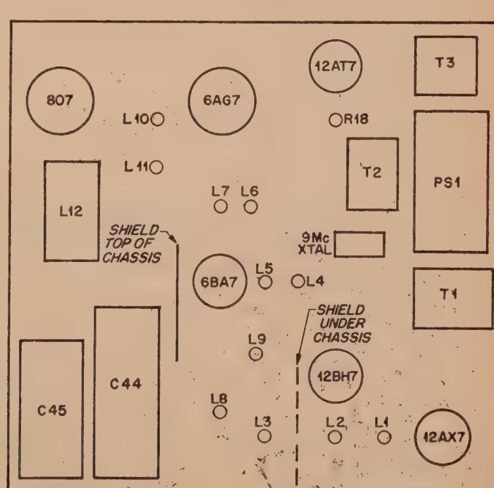


Fig. 9. Parts layout of chassis.

point, we have a low level SSB signal in the 190-550 kc region. The remaining step is to convert it to the region of the 80 meter band, and to amplify it to a useable level. The two tubes necessary to accomplish this are mounted on the dynamotor shelf at the back of the receiver.

The low frequency SSB signal is coupled via a short length of coaxial line to a 12AU7 mixer stage whose socket is mounted in one of the dynamotor mounting holes. One section of the 12AU7 is the frequency converter, and the other section is a conversion oscillator, employing a 3610 kc crystal. Using this crystal permits the conversion oscillator frequency range of 190-550 kc to beat the SSB signal to a range of 3800-4160 kc in the 80 meter region. The conversion crystal may actually fall anywhere in the range of 3450-3610 kc for proper operation.

The output of the 12AU7 second mixer stage passes through a double tuned transformer (*L14*) mounted on the side wall of the BC-453 unit, below the dynamotor well. The output of *L14* is applied directly to the input grid of a 6AG7 power amplifier stage. The 6AG7 tube socket is also mounted in a dynamotor mounting hole at the rear of the receiver chassis. The output tank circuit of the SSB transmitter also mounts at the rear of the chassis, above deck, in a small shield can.

Alignment Instructions

L1—Crystal Oscillator: Peak for max. output with PM control fully clockwise.

L2—90° RF Phase Shift: Peak for maximum output with PM control slightly off balance. Afterward adjust for equal sideband suppression with 1225 cycle audio oscillator to mike input.

L3—Balanced Modulator: Adjust for maximum output with PM slightly off balance.

L4—9000 kc filter: Adjust the same as L3.

L5—9000 kc filter: Adjust the same as L3.

L6, L7—15 Mc trap: Use Xtal at 5150 Kc or 3850 Kc. Adjust for minimum 15 Mc. output with the bandswitch in 20 meter position.

L8-L10—Adjust for maximum output at 3.9 Mc.

L9-L11—Adjust for maximum output at 14.2 Mc.

R-18—Audio Balance: Adjust for minimum unwanted sideband ripple with 1225 cycle tone applied to microphone input.

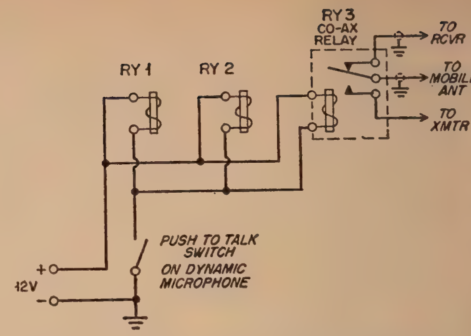


Fig. 11. Control circuit for SSB transmitter.

The complete placement of major parts may be seen in *Figures 15 and 16.*

Transmitter Assembly

The first step is to remove all the unwanted components from the receiver chassis. The entire rear end of the under-chassis area is cleaned out, with the exception of the two vertically mounted 7,000 ohm resistors (*R-22* and *R-23*). The audio transformer (*T-1*), the d-c filter components (*C-16, C-32, L-14 and L-15*) are removed as well as the dynamotor plug (*J-2*) and the power plug (*J-3*). Also remove the dynamotor mounts.

Next the resistors and wires are removed from the small under-chassis terminal board associated with the 12A6 stage. This board is between the 12A6 and 12SK7 sockets and contains *R-16, R-17, R-20 and R-21.* Remove the front plug (*J-1*) and cover, and the associated wiring to the rear plug. Remove all wiring from 12A6 socket, except white wire to *pin #7* (heater). Remove the condenser (*C-15*) over the 12A6 socket.

The next step is to remove resistors (*R-12, R-13, R-18, R-19*) and wiring from the terminal board between the 12SK7 and the 3rd i-f transformer. Remove all connections from the 12SR7 socket except the heater wires (*pins #7 and #8*). Remove all connections from 2d i-f socket (12SK7) except the heater wires (*Pins #2 and #7*). Remove the condenser (*C-32*) mounted over the 2d 12SK7 i-f socket, and *C-20,* the 3-section unit over the last i-f transformer. Finally, rotate the 12SK7 socket in the r-f stage (*V-3*) and in the first i-f stage (*V-5*) 180 degrees.

The next process is to mount the extra parts that are required for modification of the circuit for transmission purposes. First, mount a 9-pin miniature *Vector* socket (*Vector 8-N-9T*) in the dynamotor mounting hole next to the last i-f transformer (*L10-L11*). The 9-pin socket for the 12AU7 mixer stage is located in the dynamotor mounting hole farthest away from the *Vector* socket. The conversion crystal holder is mounted above-deck in front of the 12AU7 tube socket. The double tuned circuit (*L14*) in the plate circuit of the 12AU7 mixer tube is comprised of two slug-

tuned *National XR-50* coils mounted side by side on the chassis wall above the mixer tube socket, as shown in the under-chassis photo, *Figure 16*. The octal socket for the 6AG7 output stage is mounted in the dynamotor plug (*J-2*) hole between the 12AT7 and the 12AU7, and a second octal socket is mounted on the rear chassis wall in place of the old power receptacle, *J-3*. The plate circuit of the 6AG7 (*L-15*) is placed within a shield can and mounted atop the chassis, in the remaining free corner. A coaxial output fitting is placed in the rear chassis wall below the output tank circuit.

The last assembly step is to mount the audio gain control (*R-1*), the carrier unbalance control (*R-3*) and the stand-by switch (*S-1*) on a metal plate in the window in the front panel left by the removal of the front power plug. The carrier balance control (*R-2*) is finally mounted in the side of the chassis below the 6J5 tube, the position formerly occupied by *C-32*.

Transmitter Wiring

Considerable amount of wiring in the set may be used as-is, by comparing the remaining wiring with the schematic of *Figure 14*. All tube filaments should be wired in parallel, and r-f wiring between coils and tuning condensers should be done with solid wire. The coaxial line running between *L-16* and the 12AU7 mixer tube socket should have the shield firmly grounded at each end. Condenser *C1* is added to the oscillator coil *L-13* to move the oscillator to the low frequency side of the i-f passband. The actual frequency of the first oscillator is in the vicinity of 83.5 kc when the i-f transformers are tuned to 85 kc.

A small padding condenser (*C2*) is added to the cathode pin of the phase-inverter section of the 6SN7 to enhance the carrier null obtained by the proper setting of *R2* and *R3*. The remainder of the circuit is quite straightforward, a liberal use of .05 μfd bypass condensers serving to keep the r-f out of unwanted areas.

Transmitter Adjustment

Before installation in the car, the transmitter should be bench-tested with an a-c operated power supply. The transmitter requires 300 volts at 60 milliamperes for proper operation. The first step is to set the frequency of the 6SN7 beating oscillator. The second harmonic of this oscillator should be monitored with a good frequency meter, such as a BC-221. The oscillator padding condenser should be adjusted so that the oscillator covers a range of 83.5-85 kc. The 6SN7 balanced modulator should be placed in its socket, and *R2* adjusted for minimum circuit resistance, and *R3* for maximum circuit resistance. The beating oscillator should be tuned to 85 kc, and the three i-f transformers peaked up at this frequency; the coupling rod of *L10-L11* is pulled up for minimum coupling. The 6SK7 85 kc amplifier should be in its socket for this operation, and the standby switch should be closed. Alignment of the circuits may be checked by means of a vacuum-tube voltmeter placed from grid cap to ground of the 6K8 stage. The variable oscillator of the 6K8 should be checked for operation over the 275-635 kc range by means of the frequency meter, and the 85 kc oscillator signal should be observed in the 190-550 kc variable frequency amplifier. In fact, if a second BC-453

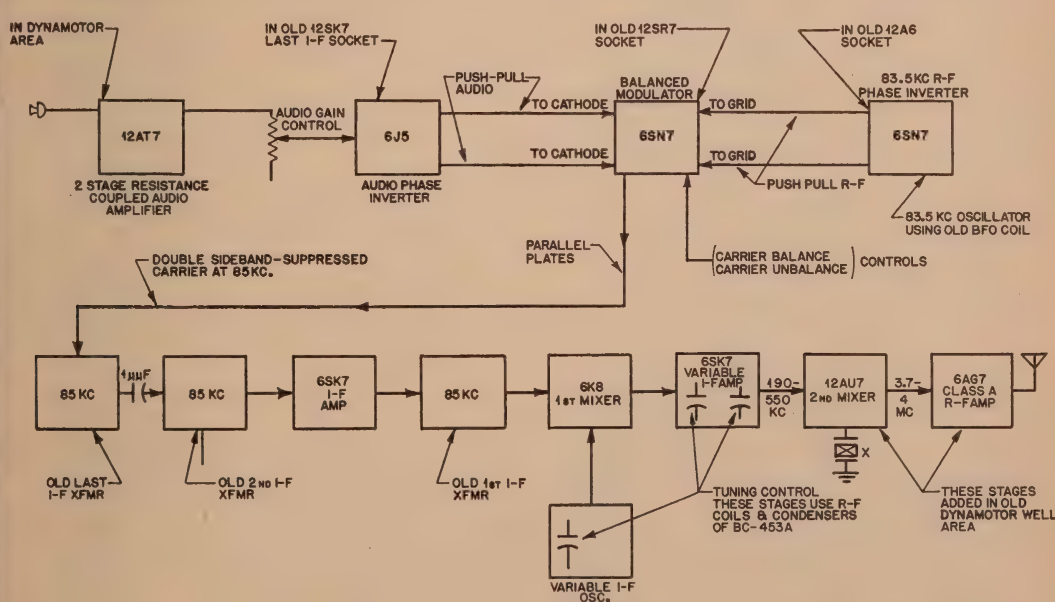


Fig. 13. Block diagram, SSB transmitter from converted BC-453A receiver.

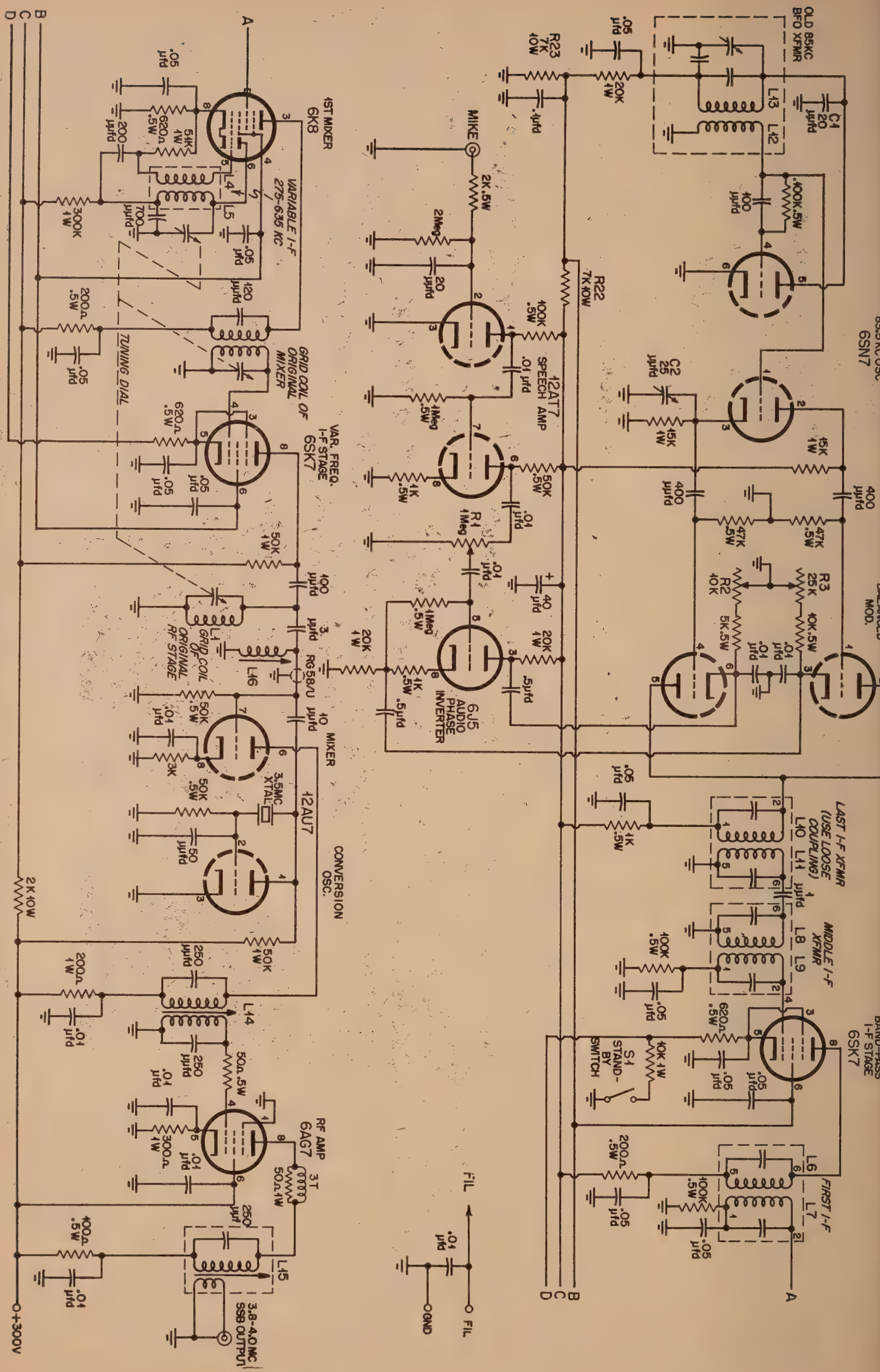


Fig. 14. Schematic, filter-type SSB transmitter made from modified Q-5'er receiver.

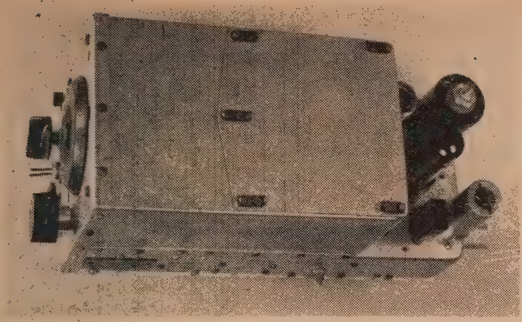


Fig. 15. SSB transmitter made from a Q-5er is well suited for mobile operation. It delivers a 3-watt SSB signal at any frequency in the 80 meter phone band. The 6AG7 is mounted in the dynamotor well area at the right.

is available, it may be tuned to the frequency of the 6SK7 variable i-f stage of the SSB exciter to monitor the signal at this point.

The 12AU7 second mixer converts the signal to a frequency in the 80 meter band. At this point, the signal may be monitored in a receiver whose antenna lead is brought near the 80 meter tuned circuits of the transmitter. A steady carrier will be heard in the 80 meter phone band. Do not confuse this carrier with the signal emitted from the 3.5 mc. conversion oscillator. Tuned circuits *L1, L16, L14* and *L15* should be peaked upon the 80 meter SSB frequency for maximum output of the 6AG7 stage.

Now, when the 85 kc oscillator is slowly tuned to a frequency of 83.5 kc, the 80 meter signal will almost disappear, since the oscillator is moving out of the passband of the low frequency filter composed of the three i-f transformers. Moving the oscillator back to 85 kc will make the 80 meter signal reappear.

The oscillator should be set at 85 kc, and potentiometer *R3* set for zero circuit resistance. Potentiometer *R2* is then adjusted for minimum 80 meter carrier at the SSB frequency. Condenser *C2* is then moved from *pin #2* to *pin #3* of the 6SN7, and adjusted at each point for minimum carrier. It should be left at the point that provides the best carrier null when *R2* is adjusted. The 6SN7 oscillator should now be tuned to 83.5 kc, and the 80 meter signal should almost disappear. When voice modulation is applied to the transmitter, the familiar SSB signal should appear on the 80 meter frequency.

The level of the low frequency SSB signal that is injected into the 12AU7 80 meter conversion oscillator is controlled by the value of the resistor in series with the standby switch. The value given provides a satisfactory level. If it is desired to raise the level, the resistor value should be lowered.

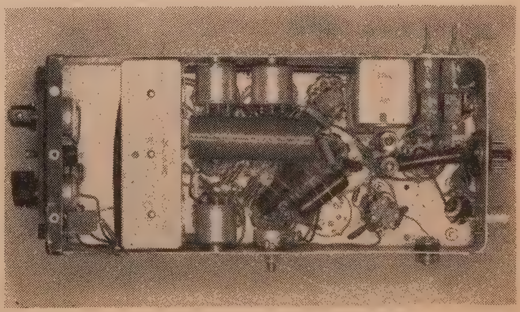
The variable tuning gang provides correct tracking across the intermediate frequency range, but *L14* and *L15* must be returned for any frequency change in the 80-meter region.

When the SSB exciter is operating properly on the bench, it may be placed in the automobile and run from the power supply of the automobile system. A SSB carrier of about 3 peak watts will be provided by this exciter.

a 60-Watt SSB Mobile Transmitter

The popularity of SSB mobile equipment is growing rapidly. A simple phasing-type transmitter is often used for spot-frequency work in the 80 meter band, providing a maximum signal for a minimum amount of primary power drain from the automotive electrical system. Shown in *Figures 17 to 21* is a compact SSB transmitter of this type, especially designed for mobile use. It incorporates a low-pass audio filter ahead of the audio phasing network to limit the audio frequencies impressed upon the network to those below 3500 cycles. In this way, the high order spurious products normally associated with phasing-type transmitters are held to a satisfactory minimum value. The transmitter is capable of peak

Fig. 16. Under chassis view of SSB transmitter made from a BC-453 "Q-5'er." The slug tuned coils (L14) of the 6AG7 grid circuit are mounted on the chassis wall at upper right. L16, the 12AU7 grid coil is not shown in this particular conversion, but is mounted in the side wall of the chassis, directly behind the midget r-f tuning condenser on the front panel. As can be seen, the under-chassis area is not unduly crowded.



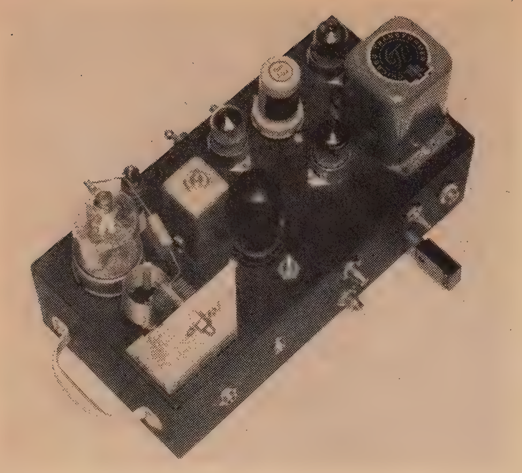


Fig. 17. This compact phasing-transmitter employs audio frequency limiting, and runs a peak input of 60 watts from a 500 volt power supply. A 6146 is used in the output stage.

power inputs of 60 watts when a 500 volt plate supply is employed, and uses only 5 tubes.

The Circuit and Layout

A top view of the transmitter is given in *Figure 17*, and a block diagram in *Figure 18*. A single 12AT7 (*V1*) serves as a two stage audio amplifier. The audio level control (*R1*) is located in the grid circuit of the second stage. The output of the 12AT7 is capacity coupled into a low-pass audio filter (*LPF-1*) which eliminates all voice frequencies above 3500 cycles. The restricted voice frequencies are further amplified by a single stage amplifier (*V2*) transformer coupled to the audio phase shift network (*F1*). The secondary of the audio coupling transformer is balanced to ground by means of a 500 ohm potentiometer connected across the winding. The audio signal is split at this point into two components, having a 90 degree phase difference between them. A cathode follower tube (*V3*) applies these two audio signals across a r-f phase shift

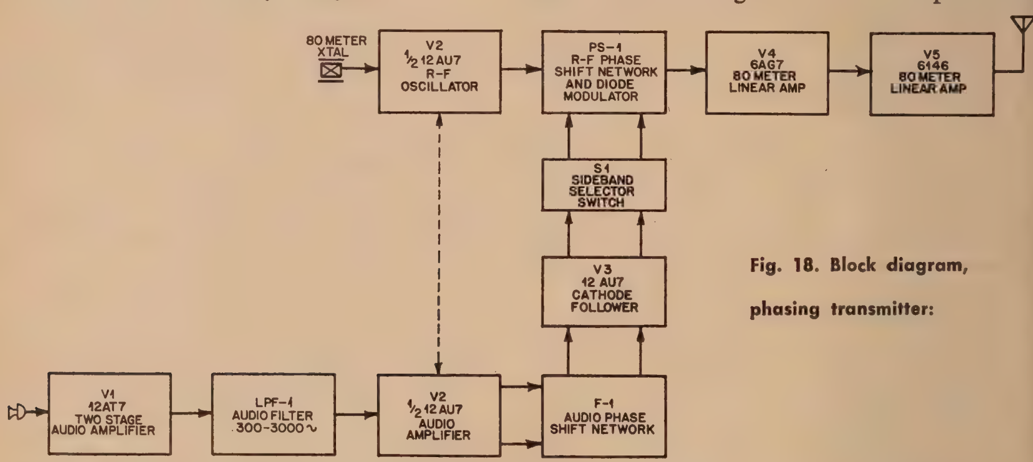


Fig. 18. Block diagram, phasing transmitter:

Parts List (Fig. 14)

C1—20 μμfd silver mica. Pads oscillator to 83.5 Kc
C2—25 μμfd mica (variable)
L2, L3—Original mixer coil
L4, L5—Original high frequency oscillator coil
L6, L7—Original first 85 Kc i-f transformer
L8, L9—Original second 85 Kc i-f transformer
L10, L11—Original third 85 Kc i-f transformer
L12, L13—Original 85 Kc BFO coil
L14—Two National XR-50 coil forms, each wound full with #22e wire. Forms spaced closely together
L15—One National XR-50 form, same as L14. Link winding 3 turns hookup wire. Mounted in shield can.
L16—0.5-2.3 mh TV-type linearity coil. J. W. Miller #6197
S1 — Standby switch, SPST
R1—Audio gain control
R2—Carrier balance control
R3 — Carrier unbalance control. Use minimum resistance for carrier null

Parts List (Fig. 19)

C1—100 μμfd midget variable
C2—50 μμfd midget variable
C3—Four .01 ufd ceramic condensers, one on each cathode pin
R1—Audio level—100 k potentiometer
R2—500 ohm wire wound
R3, R4 — 1K, 1%, one watt resistors
R5, R6—330 ohms, 1%, one watt resistors
R7, R8—100 ohms, 1%, one watt resistors
R9, R10—1K, wire wound potentiometers
L1—Primary: 8 turns #22 dcc, bifilar wound ½" diam. (see text) Secondary: 24 turns #24e, ½" diam., or National XR-50 coil form
L2, L4—24 turns #24e, ½" diam., or National XR-50 form. 4 turns #24 dcc for Link on L4
L3—35 turns, B&W Miniductor #3016, antenna tap. 5 turns from "cold" end
X1-X4 — 1N48 crystal diodes
X5—80 meter crystal
RFC—2½mh National R-100
F-1—Barker Williamson #350 phase-shift network
LPF-1—Chicago-Standard #LPF-1 audio filter
T1—Stancor A-3842. 10K to 500 ohms

All condenser valves μμf unless otherwise noted.
All resistors ½ watt unless otherwise noted.

PC—50 ohms, 1 watt composition resistor, with 3 turns #18e wire
S1—DPDT toggle switch
P1—8 prong plug
Ry1—SPDT 6 volt (or 12 volt) relay

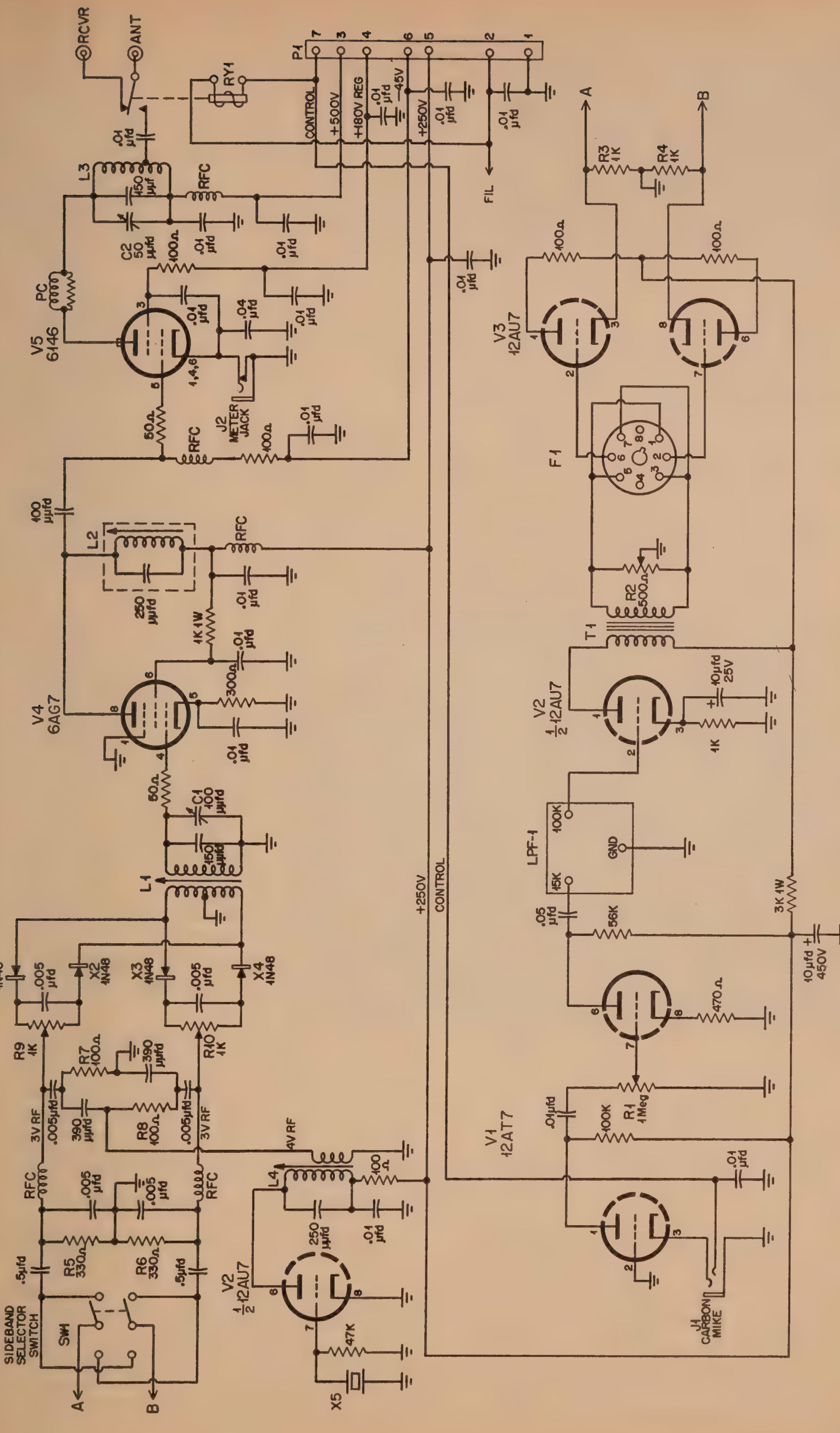


Fig. 19. Schematic 80 meter mobile phasing-type SSB transmitter.

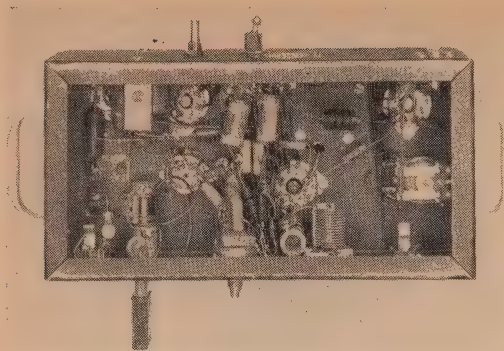


Fig. 20. Under-chassis view of SSB transmitter. The diodes of the balanced modulator are grouped around balance potentiometers R_9 and R_{10} at the center of the unit. Antenna change-over relay is at the right.

network and a diode balanced modulator. Also applied across the same network is a 80 meter r-f signal. By the proper phasing of the audio and r-f signals, a SSB signal is produced at the output terminals of the balanced modulator.

A 6AG7 80-meter linear r-f amplifier (*V4*) boosts the SSB signal to the proper level to furnish excitation for a 6146 linear output stage. The 6146 acts as a Class AB1 amplifier requiring no grid driving power, and a maximum peak SSB exciting signal of about 40 volts.

Layout of parts may be seen in *Figures 17 and 20.* At the right of the chassis are the audio filter unit and the 12AT7 speech amplifier tube. To the left of these components are the audio phasing network and the 12AU7 audio amplifier and crystal oscillator tube. To the left of the plug-in network is the 12AU7 cathode follower (*V3*). At the left end of the chassis is the 6146 amplifier stage and its plate circuit components. Between this stage and the 12AU7 is located the 6AG7 amplifier (*V4*) and its shielded plate coil.

Along the front edge of the chassis are located the microphone jack, the 80-meter crystal and the adjustment slug of the crystal oscillator plate coil. Immediately to the left of these components are located the two balance potentiometers, *R9* and *R10.* At the left end of the front lip of the chassis are the cathode jack for the 6146 stage, and the grid tuning condenser (*C1*) of the 6AG7 stage.

Located on the rear lip of the chassis are the audio level control (*R1*), the sideband selector switch (*S1*), the power receptacle, and the two antenna receptacles.

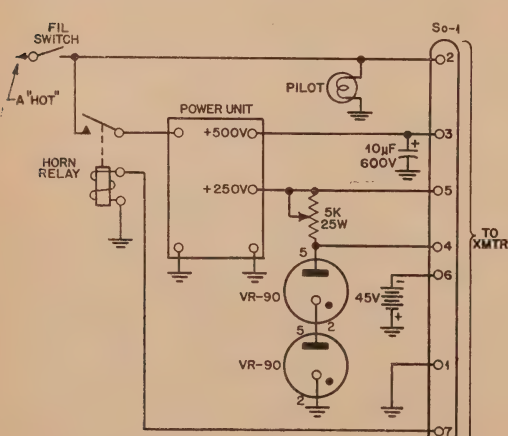


Fig. 21. Power Connections, SSB transmitter.

Transmitter Construction

The SSB transmitter is built upon an "amplifier foundation" chassis measuring 9½" x 5" x 8½" (*Bud-CA-699*). This unit consists of a regular chassis on which is attached a perforated metal cover. Handle grips are attached to the ends of the chassis. The layout of the major components of the transmitter may be seen in the top and bottom photographs.

In order to obtain maximum sideband and carrier suppression, it is necessary that certain resistors should be held to a 1-percent tolerance. Precision resistors should be used at these points in the circuit. When the resistors are wired in place, care must be taken that the body of the resistor does not become overheated by the application of the soldering iron. It is best to grasp the resistor lead, close to the body of the resistor, with a long-nose pliers. The soldering iron may then safely be applied to the lead, since the body of the pliers will act as a heat "sink", preventing the resistor from being overheated.

Small, ceramic "oystershell" condensers are used throughout the unit, with the exception of the 0.5 *μfd* audio coupling condensers (paper) and the 390 *μμfd* condensers (mica) in the r-f network. All grounds are made directly to the lugs of the tube sockets. It is necessary to make sure that each socket is grounded to the chassis, since a painted steel chassis is used.

To prevent oscillation of the 6AG7 stage, the plate coil is mounted above deck in a shield can made from a small i-f transformer. The coil slug projects through the top of the can, permitting easy resonance adjustment. The plate network of the 6146 stage is mounted above deck on a small aluminum bracket. A ¼" hole is cut in the perforated cover of the transmitter, permitting screwdriver adjustment of the plate tuning condenser, *C2*.

Preliminary Tuning and Adjustment

When the wiring has been completed and checked, the transmitter should be bench-checked before installation in the car. A power supply capable of delivering 250 volts at 100 ma, and 500 volts at 100 ma is needed, in addition to a 45 volt bias battery. Alignment of the transmitter is simple. The audio level

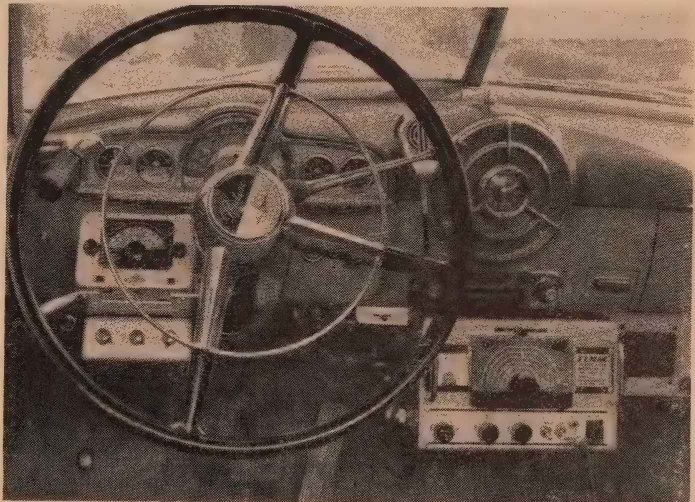
ontrol is set to the ground end, and *V2* is nserted in its socket. An 80-meter crystal of he desired operating frequency is placed in he holder, and the slug of *L4* is tuned for os- illation of the crystal stage. The 6AG7 and 146 tubes are inserted in their sockets, and a ummy load is placed on the antenna terminals f the transmitter. Coils *L1* and *L2* are tuned or maximum output, as is *C2*. The next step s to adjust *R9* and *R10* for minimum carrier utput from the 6146 stage. The two poten- iometer controls, the slug of *L1* and the tun- ng of *C1* should be all varied by small mounts, until a good carrier null is obtained *vhen L1 and C1 are still in resonance.* The ./C ratio of this tuned circuit is varied in this nanner to enhance the null balance.

An oscilloscope should be coupled to the utput of the 6146 stage, using a direct con- ection between the deflection plates of the scope and the dummy antenna load. A 1250 ycle audio signal of about ¼ volt r.m.s. is ed into the second stage audio amplifier (arm f *R1*). The 'scope is locked on the signal, and he audio balance potentiometer (*R2*) is adjusted for minimum audio ripple on the carrier. If a 'scope is not at hand, a rough adjustment of *R2* may be made by adjusting it for minimum modulation heard on the carrier when the audio tone is injected into the audio system of the transmitter.

As a final step, *R9, R10, L1* and *C1* should be "touched up" for minimum carrier ripple as seen on the 'scope. Plate current of the 6146 stage should rest at about 35 ma, rising to 120 ma under full output.

A simple control circuit for the SSB transmitter is shown in *Figure 21*. A modified PE-101C may be used for the power unit, or one of the new dual voltage vibrator supplies. It is necessary to supply a negative bias of 45 volts for the 6146 stage. This may be obtained from a small "B" battery. Screen voltage is taken from the 250 volt tap of the supply, and is regulated by means of two VR-90 tubes in series. The dropping resistor should be adjusted until about 15 ma of current flows through these regulator tubes.

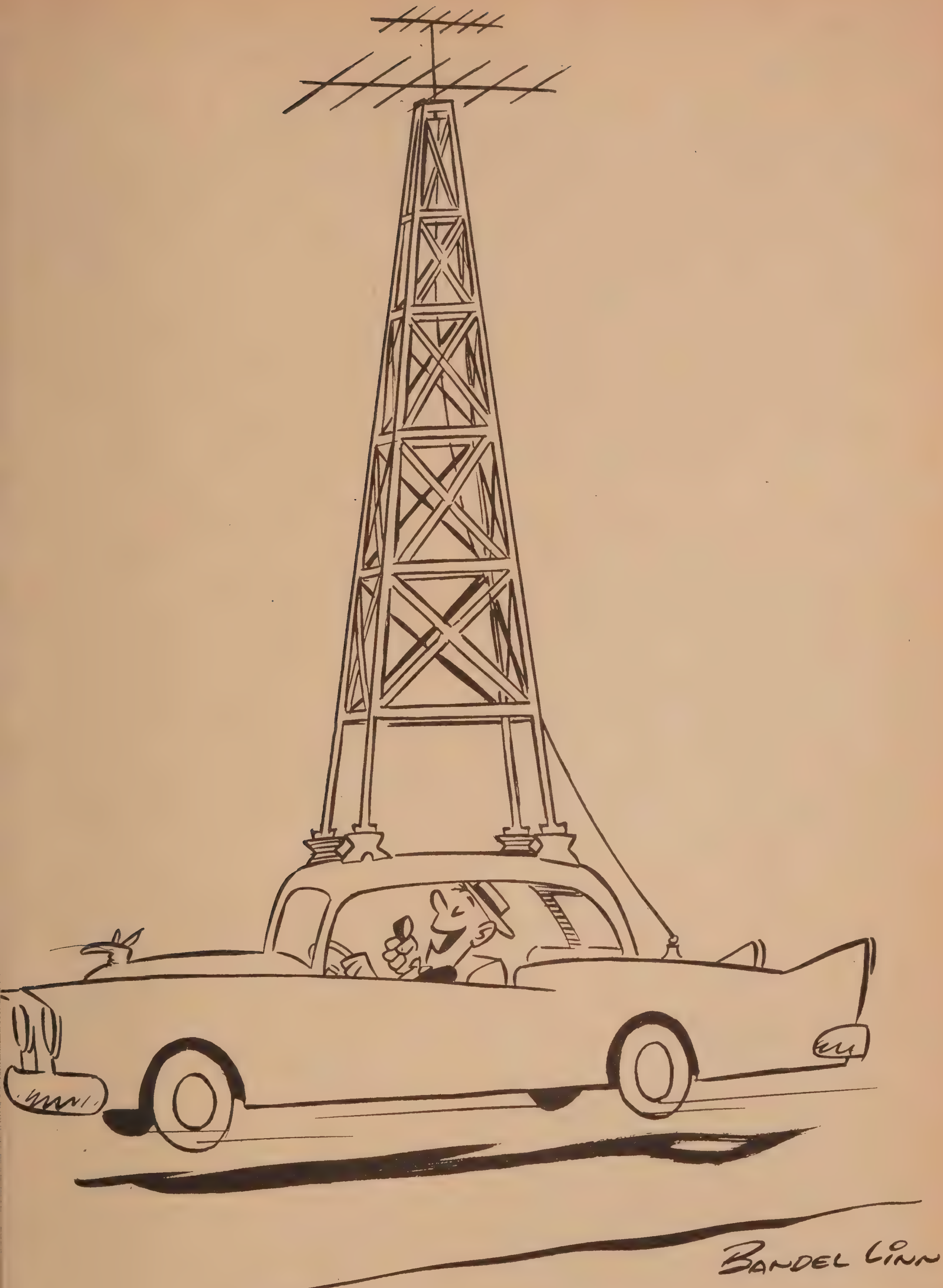
A 10 μfd condenser is connected across the output of the power supply to improve its dynamic characteristic.



he neat installation of W6NWJ/M epresents an investment of about 500. An Elmac AF-67 "Transciter" is sed as an all-band 50 watt trans- iitter. A Gonset "Super-Six" con- erter and "Super-Ciever" I-f strip orm the receiver. A Carter "Genemo- or" is used for the high voltage sup- ly, and an Elmac PSR-6 for the low oltage supply. The microphone is a urner SR-90. The antenna system is a laster "All-bander" whip with a lorrow MLV-50 motor driven base nductor. Transmitter is actuated by ither microphone switch or push- witch on floor (lower left).

Chapter Seven

Mobile Antennas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Mobile Antennas

The success or failure of mobile operation depends upon the efficiency of the antenna installation. A 10-watt mobile transmitter working into an efficient and well designed mobile antenna will out-perform a 100-watt mobile transmitter using a poorly designed antenna of low efficiency. The mobile amateur must compete with high powered fixed stations, many of them using beam antennas. The mobile Ham is thus at a distinct disadvantage. He is running low power, and he is using an antenna that often does not make the best use of his limited power.

It is the purpose of this chapter to discuss mobile antennas in general, and to illustrate some specific examples of high efficiency mobile antennas that will allow the mobile Ham to compete with fixed stations in the most efficient manner.

In the great majority of mobile installations, some kind of vertical whip is used as both the transmitting and receiving antenna. The vertical antenna has been in use for both long and short wave transmitting since 1924. It is used at v.h.f. for navigational aids and general communication. It is used at low frequencies for radio ranges and general broadcasting. During the past ten or fifteen years, the radio amateur has pioneered the use of the loaded vertical antenna for mobile transmission and reception. This is one stage of the art that is exclusively an amateur development and like other such amateur developments, has now spread to the commercial fields.

the Vertical Antenna

To understand the operation of a mobile antenna, it is perhaps wise to start the investigation with a very simple case: An eight-foot vertical copper rod with its lower end mounted an inch or so above an infinite area copper ground sheet *(Fig. 1)*. If this antenna is connected to the ground sheet through a single-turn loop of wire, and a grid dip oscillator is coupled to the loop, the *resonant frequency* of the antenna may be measured. The first quarter wave resonance will occur at about 29.5 Mc. The current distribution in this antenna is shown by the dotted line, and an equal current is flowing in the ground sheet as indicated, dropping to a very low value as the distance from the vertical antenna gradually enlarges.

By the use of other instruments, we are able to measure two other properties of this simple antenna: the *radiation resistance* and the *reactance*.

The term *radiation resistance* is very important. Briefly, it means that value of resistance which, when substituted at a current loop in the antenna system for the antenna, would dissipate the same amount of energy in the form of heat as the antenna radiates into space. The value of radiation resistance varies from one antenna to another, and varies with the relation of the antenna to surrounding objects, such as trees, buildings, etc.

In order to efficiently transfer the power from the transmitter to the antenna it is necessary to match the transmitter feed system to the radiation resistance of the antenna. For normal values of radiation resistance, this may be done simply and efficiently. For very low values of radiation resistance, such as might be encountered in some mobile antennas, it is a difficult task and *most of the transmitter power output is lost in the matching system.* This is the danger that we must be aware of in mobile work, and which requires us to put much time and effort into the design of the mobile antenna and feed system.

Keeping these ideas of radiation resistance in mind, we can make a series of measurements on and about the resonant frequency of this simple vertical antenna. At any one given frequency this antenna will present a certain value of radiation resistance, *r*, and a certain negative or positive amount of reactance, *x*. The term *reactance* indicates an opposition to the normal flow of current, and must be cancelled out or otherwise neutralized in order to allow an ef-

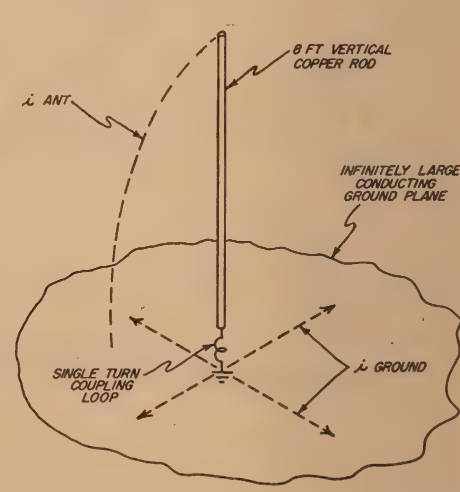

Fig. 1. A simple vertical antenna mounted above an infinitely large ground plane. The antenna current (i_{ant}) increases sinuosoidally towards the base of the antenna. The ground currents (i_{ground}) are equal in summation to the antenna current.

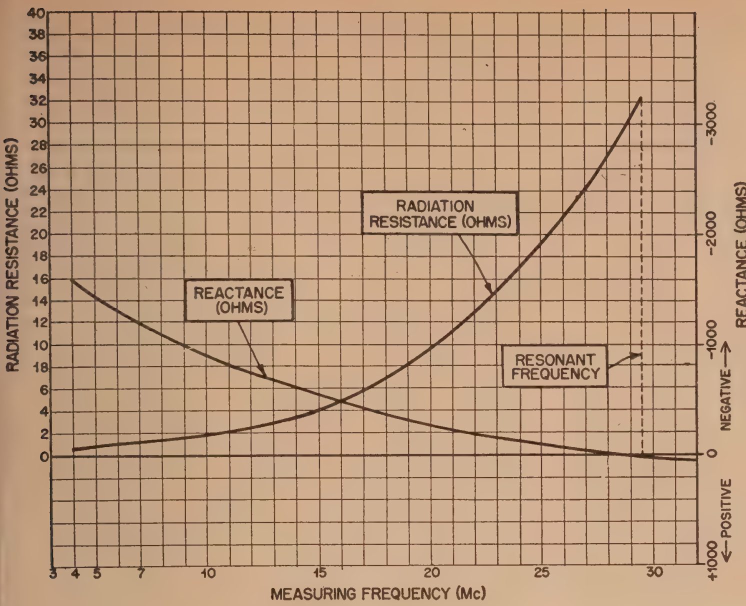

Fig. 2. Typical measurements made on an eight-foot vertical whip antenna suspendend over an infinite ground plane. The antenna is resonant at 29.5 Mc.

ficient transfer of energy from the transmitter to the antenna.

If the various values of r and x that have been measured on the eight-foot vertical antenna are plotted, a curve similar to *Fig. 2* will result.

At the resonant frequency of 29.5 Mc. the matching conditions are almost ideal. The antenna presents to the loading system a radiation resistance of 32 ohms, with no reactance. (The definition of resonance infers that the total reactance of the antenna circuit referred to the feed point is zero.) A load of 32 ohms may easily be matched to the average transmitter using a coaxial cable, with a *pi*-network, or a pick-up link. The Q of the antenna is relatively low, and the antenna will accept power over quite a wide frequency range without having to resort to complicated tuning networks. The efficiency of the antenna is very high, as the loss resistances are of the order of fractions of an ohm.

This same eight-foot rod, operating at a frequency of 21 Mc. has quite different characteristics than when it operated at 29.5 Mc. Referring to the curves of *Fig. 2* it can be seen that the radiation resistance has dropped to a value of 11 ohms, and that a negative reactance of –250 ohms has appeared. At 14 Mc., the radiation resistance of the rod has dropped to 3.5 ohms, and the reactance has risen to –600 ohms. At 7 Mc., the radiation resistance has decreased to 1 ohm, and the reactance has increased to –1200 ohms. At 4 Mc., the radiation resistance of the rod has dropped to the low value of 0.2 ohms, and the reactance has climbed sharply to –1600 ohms. These characteristic figures for the eight-foot rod are summarized in *Figure 3*.

Figure 3 tells us what we wish to know about this particular antenna. It tells us the radiation resistance of the antenna at each frequency we are interested in, and therefore tells us the load that the transmitter must be capable of matching. The chart also tells us the values of negative reactance at each frequency, and by the definition of resonance mentioned above, we know that we must cancel out or neutralize these exact values of reactance at each specified frequency. In other words, we must *resonate* the antenna to the desired frequency by adding *positive* reactance to the antenna circuit.

Resonating the Short Vertical Antenna

A short vertical antenna may be "tuned" to a frequency considerably lower than its natural frequency by the addition of a suitable inductance of the correct positive reactance that will resonate the antenna to the desired frequency. Such an inductance is termed a *loading coil.* The loading coil may be placed at any point in the antenna circuit *(Fig. 4)*. Resonance may be obtained with the coil at any of the locations shown, but the efficiency of the over-all antenna system and the ease of matching of the system may vary greatly with the placement of the loading coil. The examples in *Fig. 4* assume an operating frequency of 4.0 Mc.

In *"A,"* the loading coil is mounted at the base of the whip, in a shielded box to prevent radiation from the coil, or any form of interaction between the coil and the whip. Assume the box is of such dimensions that it does not detract from the Q of the coil. At resonance, this antenna system would exhibit no reactance,

FREQUENCY (Mcs)	RADIATION RESISTANCE (OHMS)	REACTANCE (OHMS)
29.5	32	0
21.0	11	−250
14.0	3.5	−600
7.0	1.0	−1200
4.0	0.2	−1600

Fig. 3. Summary of the characteristics of the antenna graphically illustrated in Fig. 1.

and a radiation resistance very close to 0.2 ohms.

In *"B,"* the vertical antenna is again base loaded by a coil, *L*. The coil is mounted with its axis coincident with the axis of the whip. The coil is unshielded and free to radiate. The amount of radiation from this coil is dependent upon the shape and size of the coil. The act of radiation from the coil *raises* the radiation resistance of the antenna system from the very low value of 0.2 ohm to some higher value in the vicinity of 2 ohms. This new value depends largely upon the configuration of the coil.

In *"C,"* the loading coil is mounted half way up the vertical rod. The coil and the section of the rod beneath the coil have considerable current flowing in them during actual operation, and the antenna radiation resistance is raised to the vicinity of 4 ohms.

In *"D,"* the loading coil is placed at the top of the antenna, with a capacity "hat" above it to provide capacity to ground. The radiation resistance in this case has risen to about 6 ohms.

From these examples it can be seen that the placement of the loading coil has a direct effect upon the radiation resistance of the short antenna. Since, in general, the higher the radiation resistance of the antenna system, the greater the over-all efficiency of the system, it would follow that some form of top or center loading would be best for mobile operation and that base loading in any form is to be avoided, if possible.

Placement of the Loading Coil

Figure 5 shows the four examples of *Fig. 4*, with the addition of the curves illustrating the current distribution of each antenna.

The radiated field surrounding an antenna, other things being equal, is proportional to the current flowing in the antenna, and to the length of the antenna carrying this current. The short vertical rod radiating the best signal, therefore, will be the one that has the most current flowing in it per unit of length. In *"A,"* of *Fig. 5*, the whip impedance is very high, and the current flowing in it is very low. The buildup of current occurs in the loading coil. Since this coil is shielded, this coil current cannot aid in any way to the radiation of the antenna. In *"B,"* the same coil is unshielded, and the current flowing through it is partially radiated. This act of radiation raises the radiation resistance of the whole antenna system a certain amount. In *"C,"* a high current flows in the section of the antenna beneath the loading coil, so the bottom section of the antenna contributes materially to the total radiation from the antenna system. In the ideal case, *"D,"* the loading is all at the top of the antenna. The maximum current is flowing in the total length of the antenna, and the strongest external field results from this action.

The Fractional Wavelength Vertical Antenna

Mathematical studies on a very short vertical antenna suspended above a ground surface show the antenna to take the form illustrated

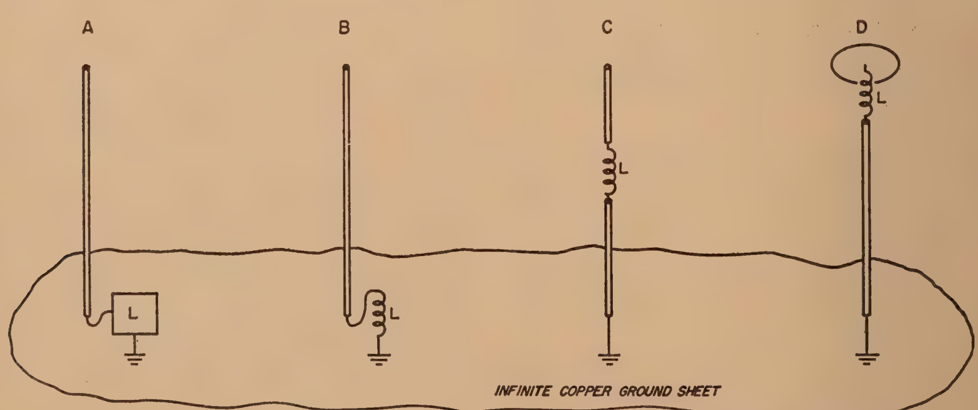

Fig. 4. A short vertical antenna may be resonated at a lower frequency through the insertion of an inductance or "loading coil." In "A" the loading coil is mounted in a shielded and grounded box. In "B" it is unshielded and mounted at the base of the antenna. In "C" it is unshielded, but mounted in the center of the vertical antenna. In "D" the coil is at the top of the vertical antenna with a "top hat" capacity arrangement.

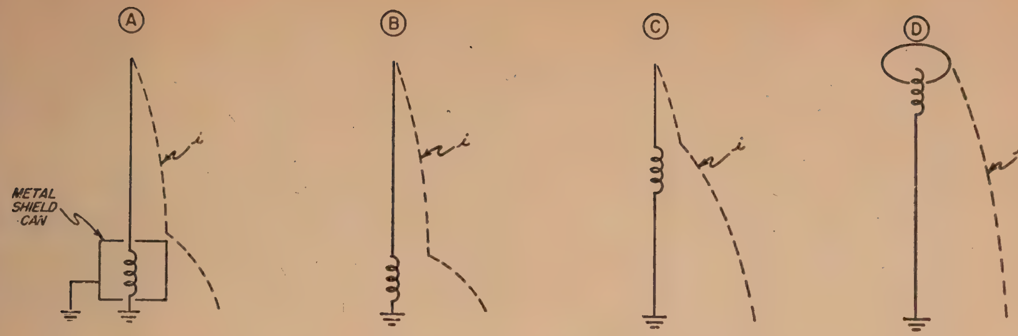

Fig. 5. Current distribution of the four types of "loaded" vertical antennas shown in Fig. 4.

in *Figure 6*. Such an antenna exhibits strong capacitive reactance to the measuring device (an r-f bridge), inserted between the base of the antenna and ground. The equivalent circuit of *Figure 6b* shows the resistances which dissipate the power applied to the antenna. The most desirable resistance, of course, is the radiation resistance of the antenna, designated R_r. For straight whip antennas this value is a function of the height of the antenna and may be expressed as: $R_r = \frac{H^2}{312}$

when H is the height of the antenna in electrical degrees.

This expression may be plotted in a graph form, as shown in *Figure 7*.

The various other resistances shown in *Figure 6b* are less desirable, and form the lossy elements of the antenna. The first of these is ground resistance, R_g. On automobiles, the ground circuit is indistinct, looking like a low grade capacitor in series between the automobile and the surface of the road. This capacitance and its resistance may be measured just like any other, by a suitable impedance bridge. A suggested means of reducing ground loss is the use of a copper screen fastened to the undercarriage in the style of bottom covers used on racing cars.

The next antenna loss to consider is the resistance of the loading coil, R_L. This loss is a direct function of the Q of the loading coil, or the relation between the inductive reactance (X_L) of the coil and the r-f resistance (at the frequency of operation): $R_L = \frac{X_L}{Q}$

Even with Q's as high as 400, more power is usually devoted to heating the loading coil than making signal. Obviously the coil should be the most efficient possible. Coil Q is measured with a Q meter.

Next on the list of losses is the ohmic resistance of the conductor making up the antenna, R_o. This consists of d-c resistance multiplied by a skin-effect factor. With thin or poorly-conductive antennas this figure can be quite large, compared to radiation resistance.

Capacitance at the base of the antenna soaks up power. Although this loss is through a shunt circuit, it is evaluated easiest when transformed to a series equivalent R_c*-shunt* as shown. The greatest loss source here is the base or lead-in insulator, and how much loss depends upon whether the insulator is above or below the loading coil in the circuit.

Here is how this works: Reactance of the base capacitance is looked on as resistance of the same ohmic value, through which current flows to ground. Current leaving the circuit by this route never reaches the radiation resistance, which is where we want it dissipated.

As in a real resistance, current flow through this shunt depends upon voltage impressed. Now, with the usual rig, voltage at the bottom of the loading coil is in the order of tens of volts. However, at the top of the coil voltage is in the order of hundreds or even thousands of volts. The result is that a moderately-capacitive insulator above the loading coil introduces an equivalent series resistance of ohms. So use a low-capacity base insulator, and keep loss low by placing the loading coil above it in the circuit.

Similarly, base-insulator dielectric leakage introduces a series equivalent resistance, R_d:

$$\text{Series Equiv. } R_d = \frac{R^2 + X^2}{R_d\ (\text{shunt})}$$

If the base insulator is located below the coil, a point of low reactance (and low voltage), loss will be negligible. But if the base insulator is above the loading coil, a leakage resistance of hundreds of thousands of ohms, or even megohms, introduces a loss equivalent to that which would be suffered in a series resistance of a husky fraction of an ohm, and in severe conditions, many ohms. Hygroscopic insulators are worst in this respect, but any insulator causes trouble if it is wet or dirty.

Sometimes another loss resistance is encountered—that due to absorption of mutually-coupled circuits, R_m. This is most prevalent in maritime-mobile operation, although it is suffered on planes, and in some cases in auto operation. Rigging, structural members, or other antennas are contributory. If other conducing objects cannot be kept out of the im-

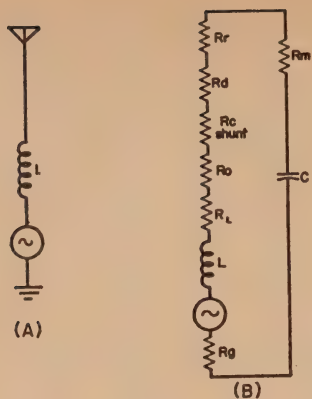

Fig. 6. Electrical equivalent of short vertical antenna.

mediate field of the antenna, it is imperative that they have a different resonant frequency, and that they are either "floating" or efficiently grounded. A coupled circuit having a low internal resistance returns some of the energy it soaks up back to the field, where the worst result is a pattern distortion. But an absorptive circuit with loss resistance of its own just soaks up power.

Until now, we've talked only of symbolic configuration of the short antenna. Let's go from symbols to actual hardware. What shape should the antenna have?

In the first place, no one design is best for all conditions. All we hope to do is arrive at something reasonably good for our own particular case. Physical and mechanical considerations are sometimes as important as electrical design, and the most efficient structure might not be satisfactory if it is offensive to the eye or if it is unsound aerodynamically.

But let's assume that through careful construction, we keep controllable losses to a minimum. Is there anything better than the plain whip we have thus far considered?

Figure 8a shows current and voltage distribution in an antenna with the coil at the bottom. If the main portion of the antenna carried more current, radiation figure and pattern would be improved. The most common means of raising the high-current section of the antenna is to move loading inductance upward, giving current and voltage distribution as in *Fig. 8b*.

However, this can't be done blindly, or any gain is gobbled up by increased losses.

Actually, radiation resistance and capacitance are not lumped, but are spread along the entire antenna, as shown by *Fig. 9*. With the loading coil in position (1), it is resonated by the entire capacitance of the antenna.

But note that if the coil is placed at points (2), (3), (4), or (5), corresponding to increasingly-higher positions aloft, it faces less and less capacitance. Therefore, to resonate the antenna, the coil must be increasingly larger as it is raised. With the standard of construction remaining constant, resistance of a coil naturally increases as it contains more and more wire. Hence, a point is reached where gain in radiation resistance or pattern is offset by mounting coil loss.

For example, a whip that resonates with a 20-turn coil at the bottom may need 70 turns farther up. And, at the very top, the coil stops acting like an inductance and turns into a low-grade blob of capacitance, so inductance must be added below to resonate the system. Any "gain" in such a case is highly problematical.

When using coils aloft, remember that snug metal shields, dirt, or moisture also increase coil resistance. The antenna-loading coil should have the maximum *Q* attainable, no matter where it is placed in the circuit.

Now let's examine antenna loading from another angle. If the antenna capacitance (other than at the base) is increased, the amount of loading coil required for resonance is reduced, and coil loss with it. *Figure 9* also shows that the best place for the bulk of capacitance is at the end, since to reach this capacitance current must flow through the entire antenna, utilizing the entire radiation resistance. Unfortunately, the end is the poorest location mechanically. Fixed stations get by with "wagon wheels" atop the antenna, but not the family bus.

Antenna capacity can be raised by increasing diameter. A thin whip may have a capacitance of 20 $\mu\mu$fd. Increasing diameter to 1″ raises capacitance to 40 $\mu\mu$fd. Thin-wall tubing of 3″ diameter has almost twice this value. These "thick" structures need not be solid—lattice construction has an equivalent effect.

Increased capacity is realized by "fanning" two or more whips at an included angle of not

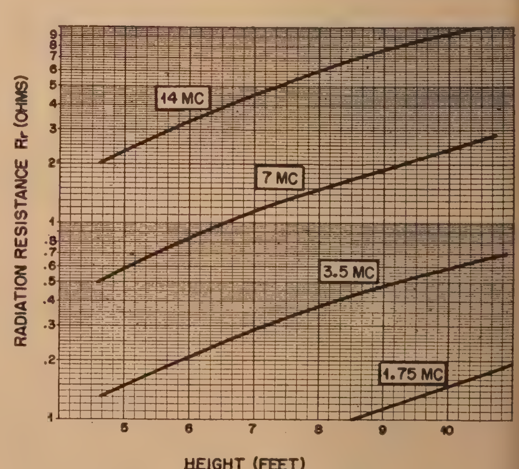

Fig. 7. Graphical representation of radiation resistance of short vertical antenna above perfect ground.

more than 60°. This arrangement is light and has more top loading than cylindrical shapes, and it can be accommodated on rear deck or bumpers. But, however we get it, capacitive top loading can reduce the amount of inductive loading required by more than one half with a consequent lower coil loss.

The relative distribution of transmitter power, and hence, efficiency of different antenna configurations, can be checked without complicated instruments. Using a dummy antenna, find transmitter-power output under standard load conditions. Then measure base antenna current with the same transmitter input. Total antenna resistance is found from the formula:

$$R_t = \frac{P}{I^2}$$

Comparing measured resistance of different elements of the system with this total gives an idea of the loss in each part, and dividing radiation by total resistance will show relative antenna efficiency. Resistances of different coils, ground systems, and radiators can be checked by this means.

The Eight Foot Whip and the Automobile

Some very important changes take place when this eight-foot vertical rod, or whip, is removed from the infinite copper ground plane and mounted on an automobile. The whip is not now operating with a low-loss ground system. It is operating against the car body, which is finite in size, and insulated from ground by the rubber tires of the automobile. The body of the car is not at ground potential, and therefore radiates some energy. This is important, as it alters the pattern of the whip antenna *(Fig. 10)* and also helps to raise the radiation resistance of the antenna system on the lower frequencies. Different measurements taken on a 9-foot whip at various frequencies are shown in *Fig. 11*. *Curve A* is the radiation resistance of the whip alone, over an infinite ground plane. *Curve B* is the radiation resistance of a typical *bottom loaded* whip mounted on the rear of an automobile. *Curve C* is the radiation resistance of a typical *center loaded* whip mounted on the rear of an automobile. *Curve D* is the actual measured *radiation resistance and loss resistance* curve for a center loaded whip, mounted on the rear bumper of a 1950 *Ford* coupe. The *loss resistance* consists of the r-f resistance of the car and the antenna, and the losses in the loading coil. Of these losses, the loading coil losses are by far the most important. At 4 Mc., the loss resistance of this particular 9-foot whip and loading coil was 6 ohms, and the radiation resistance was 8 ohms. The load presented to the transmitter was 14 ohms. The efficiency of the antenna is 8/14 x 100, or 57%. This is extremely good efficiency at this frequency, since many 4-Mc. loaded whips have efficiencies in the neighborhood of 5% to 20%.

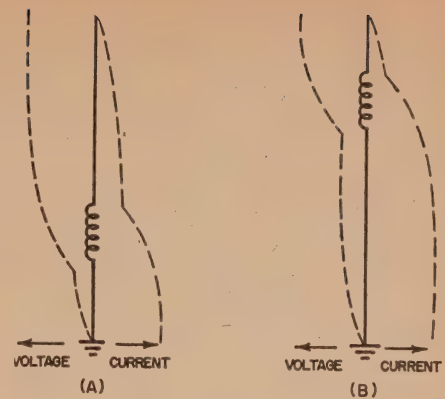

Figure 8.

As the operating frequency of the loaded whip is raised, the size of the loading coil diminishes, and it is easier to construct an efficient loading coil of good *Q* without it being too large in size for a mobile installation. At 7 Mc., for example, with the proper loading coil, this same antenna has a coupling efficiency of about 70%. At 14 Mc., the efficiency rises to 85%, and at 28 Mc., the antenna will radiate practically all the power fed to it.

The importance of center loading mobile whips at low frequencies may readily be seen by comparing *Curves B* and *C*. The importance of having a good, efficient loading coil may be seen by comparing *Curves C* and *D*. A low efficiency loading coil would tend to push *Curve D* higher on the graph. The power wasted in the loading coil is represented by the vertical distance between *Curves C* and *D*. Using a loading coil that is 100% efficient would result in *Curve D* falling exactly on top of *Curve C*.

The Loading Coil

The all important loading coil is the heart of the loaded low frequency whip antenna. Its purpose is to cancel out the negative reactance offered by the short antenna to the tuning device. The shorter the whip antenna, compared to a quarter-wavelength, the greater the negative reactance offered to the tuning device. A loading coil adds an equal and opposite amount of positive reactance to the antenna circuit. This will neutralize out the negative reactance of the short whip, leaving only the radiation resistance of the whip and the inherent losses of the loading coil as the terminating load for the tuning device.

Unfortunately, most loading coils are far from perfect—they exhibit resistance as well as reactance. The ratio of the reactance to the r-f resistance is given by the symbol *Q*. A coil having a reactance of 1200 ohms (for example an 80-meter loading coil), and a resistance of 10 ohms is said to have a *Q* of 120. If this coil is used with an antenna having a radiation re-

sistance of, say, 8 ohms, the coupling efficiency is then 8/(8 + 10) x 100 or 45%. Over half of the output power of the transmitter is lost in the loading coil. If the radiation resistance of the antenna is only 4 ohms (as it may well be with base loading), the coupling efficiency is then 4/(10 + 4) x 100 or 28%. This means that 72% of the transmitter output power is being lost in the loading coil. This power can only be dissipated in the form of heat. Small wonder that many loading coils burn up when 50 or 100 watts of r-f are applied to them!

To improve the efficiency of the loaded whip means increasing the radiation resistance of the antenna by using center or top loading, or raising the *Q* of the loading coil.

This brings us to the meat in the nut in mobile antenna design which is the loading coil. All of the before-mentioned factors can be perfected to a high degree, but if very great care and attention is not paid to the loading coil, nothing will have been accomplished. It has been truthfully said that right here the success or mediocrity of the mobile antenna is determined. In coil design and construction there is considerably more than meets the eye. It is, in fact, quite impossible to visually inspect a coil and guess correctly what its efficiency is. One little design defect at this point can turn the 50-watt transmitter into a poor 25-watt one. A single, seemingly unimportant correction can readily double its effective power.

Q

Fundamentally, we must have a loading coil of the highest possible Q with the smallest possible physical dimensions. This is a big order, but we obviously cannot stand a large coil because of weight and wind resistance again building up the sway and lean. We must have very high Q in order to insure lowest possible loss resistance. Careful design consideration and intelligent selection of the best compromise is in order. Other considerations also are present. A mobile antenna, for example, that is a "fair weather" device only, is not too desirable. The only answer to this problem is sealing the entire loading coil in some manner so that in the rain there is no change in dielectric or conductor diameter, which in turn would cause detuning. This means, of course, complete sealing of the hermetic variety and not simply surrounding the coil with shields that breathe, leak, sweat, or just look good. What self-respecting amateur would subject his final amplifier tank circuit to rain, dust, and varying humidity in saturated salt spray and expect it to remain efficiently in tune while swinging across the countryside over varying earth conditions? In a measure this antenna loading coil is also a delicately balanced tank circuit, must be well protected, and should be treated with respect. You can pick up 3 db. or more by doing so.

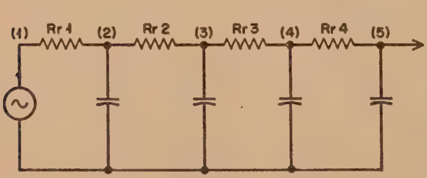

Fig. 9. Distributed resistance and capacity of short antenna.

Form Factor

Time and effort spent in designing a really efficient loading coil will pay off handsomely. Form factor must be taken into consideration along with proper mechanical support and many other things. An "air-wound" coil is always preferable to one supported by a solid dielectric. The largest possible wire diameter should be employed consistent with practicability of the finished product, the power level involved, and the frequency of operation. It is, for example, useless to end up with a coil having definitely superior electrical qualities if this coil is so huge as to cause excessive wind resistance and have such weight that the antenna supports will not carry it.

Good compromise calls for the lower frequency band coils to be wound with number 18 wire, the medium frequency band coils to be wound with number 14 wire, and the higher frequency band coils to be made of number 12 wire. In each case good form factor demands that the coils be about twice as long as their diameter. These "air-wound" coils can then be supported within sealed insulating tubes having sufficiently high strength to withstand the rigorous treatment to which they will be subjected. They should not be sealed within metal housings nor should they be encapsulated within a solid dielectric material.

A newly developed series of coils of this type is sealed within chemically-welded acrylic housings from which the air has been removed by vacuum pump and then replaced with pure helium. This makes them impervious to moisture change, dirt, salt spray, and the like, and assures constantly high operating efficiency. Coils of this type have a measured Q of better than 400.

Optimum Dimensions

For those fortunate enough to have access to good test equipment, including a high quality Q-meter, the following tabulation of inductance and dimensions is sufficient to enable them to build their own coils for each band:

Band	Microhenries	Number Turns	Wire Size	Diameter
75	107	55	#18	2½"
40	32	30	#14	2½"
20	7.5	11	#12	2½"
15	1.85	4	#12	2½"

These coils should be of the air-wound type, rib supported, with the turns spaced about the

diameter of the wire. In all cases they are based on using a 36″ lower support rod and a 60″ top whiprod. Some final adjustment will be required after installation due to differences in winding technique, distributed capacity, and other factors. When a mobile antenna is installed the coils should be left alone if they have been properly designed in the first place. It is never advisable to upset their form factor or in any way chance destroying the Q of the coil. Adjustment of the antenna to frequency can be made quickly and easily by top rod adjustment. If coils are made in accordance with the charted data, very little frequency adjustment will be required.

Multi-band Operation

At this point it will be apparent to the reader that we have been discussing individual loading coils only. One for each band employed. This section is concerned only with designing the best possible mobile antenna from which the greatest possible radiation can be obtained. All multiband loading devices must sacrifice efficiency in favor of convenience. There has never been built a multiband loading device that can begin to approach the efficiency of the antenna system herein described. The shorting of a single turn in the loading coil can chop the Q in half. Anything inserted in, or near, the coil field will put you right back where you started, or worse. Sliders, rods, switches, variable condensers, slugs, taps, clips, or even a piece of wire, if inserted within the field, will start the process of Q destruction, loss resistance increase, and field strength reduction. By using individual coils we are shooting at maximum possible efficiency. Convenience must therefore be sacrificed. Take your choice. You can either have a very good "one coil per band" antenna or a relatively poorer "all band" model. You cannot have both.

The *average* mobile installation is not of the calibre where quick band-change, including the antenna, can be accomplished while the vehicle is still in motion with any degree of safety or convenience anyway. This type of mobile operation is coming, but it just is not here yet. The *average* mobile installation is a single band affair, or, at least, is primarily used as such. For the time being the only answer to antenna efficiency lies in having a set of good loading coils, one for each band employed, and, if you want to live to a ripe old age, stop your car and change both at the same time, equipment and antenna coil, when shifting from band to band.

Preliminary adjustment of the antenna can be made with a grid dip meter. Final adjustment should never be attempted with this instrument. If you have made your coils in accordance with the chart, you will probably find that using the grid dip meter at all is simply a waste of time. You will probably be able to insert them, one after the other, and discover that your antenna "loads" with all of them. We are, however,

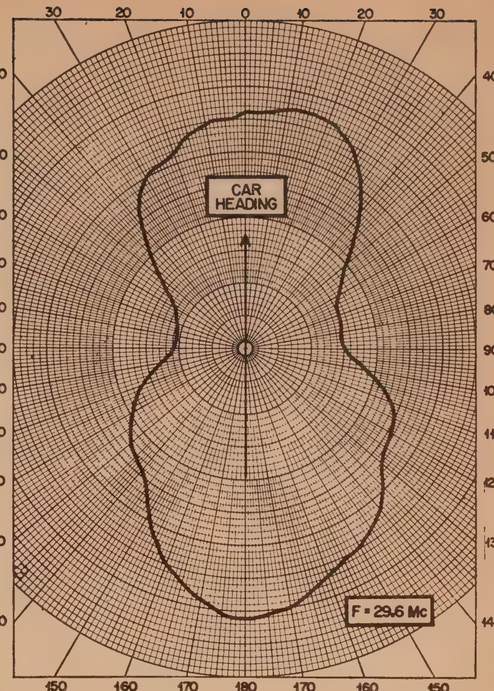

Fig. 10. Polar plot of a resonant short vertical antenna mounted on the left rear bumper of an automobile.

shooting at considerably more than just "loading" which is not an expression of radiation efficiency. It is, however, a step along the way. What we want is a set of coils to cover all amateur bands when used with the same top rod length. The chart is designed to give you such a set of coils. It is more difficult to secure resonance within the 75-meter band than in any other band. This is the place to start checking.

Special Problems Encountered on 75 Meters

The 75-meter coil shown on the chart is designed to center, with the rod lengths stated, at 3900 kc when operating, and not by grid dip measurement.

You should fire up your transmitter and determine that it will center there. It will cover approximately 50 kilocycles either side of this center with fair efficiency although it should be used on center for maximum efficiency. This may be all of the 75-meter band you will ever care to cover. If it is not, and you wish to cover the entire band, you must resort to capacitive tuning.

It is not possible to design one coil, or one antenna, with sufficient bandwidth to provide anything resembling efficient operation over such a wide frequency range as the entire 75-meter band or even between 3800 kc and 4000 kc. You cannot tap the coil and move inductively. You cannot place a variable con-

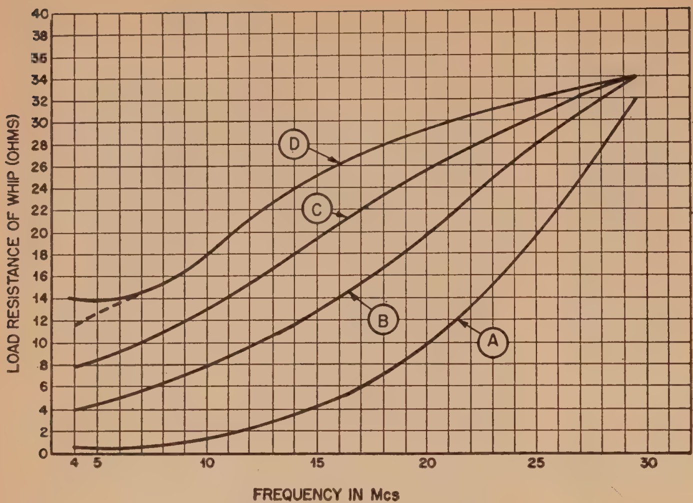

Fig. 11. Radiation resistance curves of typical 9-foot mobile antennas with various types of loading. Curve "A" is the resistance if the antenna were mounted above an infinite ground plane. Curve "B" shows a base loaded vertical mounted on an automobile. Curve "C" is the same antenna, but now centerloaded. Curve "D" is the radiation resistance and loss resistance of a center-loaded vertical antenna on a 1950 Ford coupe.

denser in, or near, the coil field. You cannot place an adjustable slug within the coil. There is only one answer. The distributed capacity of the entire antenna system must be changed or the inductance must be changed. In either case, this means that the top tuning element, above the coil, must be modified. There is nothing you can do to the coil and there is nothing you can do below the coil that will not tend to lower the antenna efficiency. This includes inserting variable inductors, motor driven or otherwise, at the base of the antenna.

Top Loading

The addition of a very small capactive device, "hat," strip of aluminum, wire, or rod firmly attached to the top whiprod is the only good method. *(Figure 12)*. When this is attached it then becomes necessary to adjust the top rod length in a manner so that with this device located some distance up the top rod, you can achieve resonance at the 4-megacycle end of the band. The device can then be moved down the top rod, closer to the coil, to predetermined locations, for satisfying resonance at lower frequencies in the band. This hat will cause some swing and sway and is to be recommended only for those who must cover the entire band quickly and are willing to sacrifice some efficiency to this end. A better method is to carry along more than one top rod and change to a different length if necessary. You will experience no difficulty at all in covering the other bands higher than 75 meters with but a single rod and without tuning devices. This complication is applicable only to the 75-meter band.

On the subject of top rods, here too the best compromise must be selected. The top rod is essentially a tuning element and not a radiating one. Most effective radiation takes place below the loading coil.

Whipping around of the top rod can cause more detuning, mismatch, changing plate loading, and SWR, than motion of any other antenna section. If the top rod "leans" this can usually be compensated for by equipment adjustment. If it wobbles all over the sky while you are driving you are licked. A heavy metal top rod is definitely not the answer. A slim, stiff, lightweight metal rod is better. The newer, very lightweight fiberglas top rods are better yet. Standard fiberglas rods of the proper length are now being made that will stand up practically straight at any car speed and will not flounder around when the brakes are applied. If you select one, make certain that it is equipped with a metal corona ball and not one of plastic. With a really high-Q coil at 4 megacycles you can actually burn the plastic ball right off the top of the rod.

Final Adjustment

Now for final frequency adjustment of the antenna. Again let us say that if your coils have been properly made in the first place, it is a serious mistake to prune them. Set up the antenna and fire up the transmitter. With antenna resonance somewhat on the low side, which is where it will be, you are ready to go. If you use a pi-net output circuit in your transmitter it is a relatively simple job at this stage to trim the antenna to exact frequency. With the antenna somewhat on the low frequency side it will exhibit inductive reactance and the transmitter will "load" only with a minimum of pi-net loading condenser. By trimming the top rod, fractions of an inch at a time, the pi-net loading condenser will start coming in and more capacity will be required each time the rod is trimmed. When you arrive at a point where from 300 $\mu\mu$fd to 500 $\mu\mu$fd is being used to properly load your final, you are there. Go no further, it is tuned.

If you have made your coils according to the chart, you can now shift from coil to coil and you will find that your antenna is properly adjusted for all bands. About the same amount of pi-net loading condenser will be used on each band. This is the time to begin finding out what you really have accomplished.

This is not too easy to do. Right here you need a lot of expensive test equipment or, in lieu thereof, a lot of patience. If you do not have access to the high quality test equipment, you may be forced to test your antenna in "on the air" measurements. These can never be wholly relied upon and depend to a great extent on band "conditions" over an extended period of time. At any rate if you cannot secure high quality test equipment, do not get any. Even the best is not yet good enough in many respects.

Impedance/Efficiency

Many comparative measurements have been made with a representative antenna built in accordance with the data contained herein. Using a General Radio Model 916A bridge, this antenna will exhibit a terminal impedance of 25 ohms. The average mobile antenna employing a coil of poor form factor, and half the Q, and wound on some poor dielectric, will hardly achieve half this impedance. Most will measure 10 ohms or less. At a specified power input level the base current of the 10-ohm antenna will be somewhat less than the base current exhibited by the 25-ohm antenna as measured with a radio frequency ammeter. So there you are, and where are you? You have an antenna power better than twice as great and with the same power input. You have just managed to get something for nothing and you should feel pretty good about it.

Feed Line

There are a number of ways of feeding power from the transmitter to such an antenna. They have been adequately discussed elsewhere and often. A very short length of RG-8/U is customarily employed. If longer lengths are used there is always the possibility of running into reactive difficulties. In such cases the best bet is to use a one-half wavelength line of RG-8/U. In any case, the antenna being 25 ohms, there is always the possibility of using two identical lengths of RG-8/U in parallel and coming up with a "perfect" impedance match. Handbooks should, of course, be referred to for methods of feeding. Here we are interested only in having something to feed.

Follow closely the suggestions contained herein and you can come up with a mobile antenna that will enable you to pick 3 db. or more, as compared to "just another mobile antenna" as a reference. You will discover that communication can be maintained where the usual mobile system fails.

Do not be surprised if you cannot successfully compete with a fixed station on the same frequency using a kilowatt and a three element beam. A few kc away from his frequency, however, you will find that you can work nearly everything that he can. An antenna of this design has been instrumental in working WAC mobile over and over again. It has worked Australia the long way around in the middle of the afternoon, and has worked western Australia, the furthest point on the globe from the East Coast, the short way around at midnight, right through the West Coast QRM.

Amateur Utopia can be defined as possessing an antenna system capable of working anything you can hear. With this antenna many calls have been answered by stations that were actually too weak to copy. What more can anyone ask for?

Practical Mobile Antennas

The usual mobile whip antenna used on the high frequency bands requires little or no loading to resonate it to the operating frequency. The radiation resistance of such resonant whip antennas for these frequencies is in the order of 25 to 35 ohms.

According to formula, a resonant whip for 10 meters should be between 8′4″ and 7′11″ long, depending upon the operating frequency in the 10-meter band. This is not strictly true, as a ¼-wave whip working in conjunction with a car body does not act as a true ground plane on 10 meters. The car body distorts the true circular pattern of the whip, and also alters the radiation resistance and the true resonant length of the whip. Typical measurements on several mobile installations indicate deviations from the accepted whip lengths of as much as

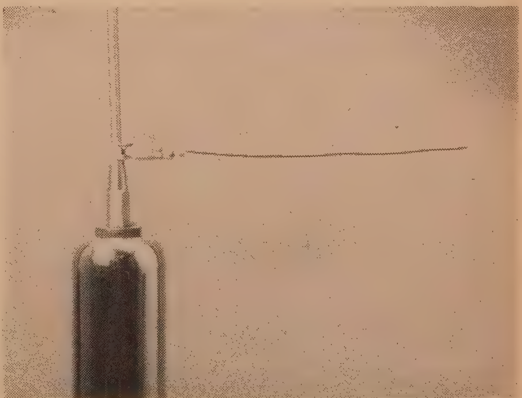

Fig. 12. A detachable pigtail permits frequency shift of 80 meter mobile whip.

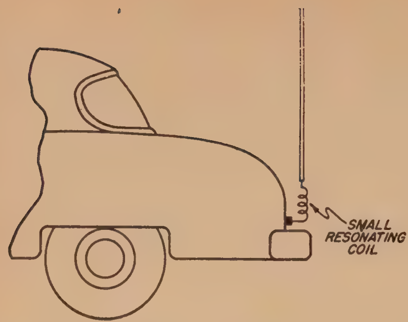

Fig. 13. The effective "length" of a whip antenna on 10 meters may be changed by adding a small resonating coil at the base.

one foot to obtain resonance at the desired frequency.

It is very important that the whip antenna be resonant near the operating frequency. If the whip length is fixed, additional "length" may be added to it in the form of a small coil, wound of No. 12 enameled wire, about ½″ diameter between the base of the whip and the coaxial line *(Fig. 13).* The number of turns in this coil are adjusted until the antenna resonates at the correct frequency. If the whip is too long for the desired operating frequency, a variable condenser of 200 $\mu\mu$fd. capacity may be placed between the base of the whip and the coaxial feed line. This condenser should be adjusted until the antenna resonates at the desired frequency by coupling the whip to ground through a two-turn coil and using a grid dip oscillator.

Extended 10 Meter Whips

It is possible to use an extended length whip antenna on 10 meters for improved performance. A whip that is longer than ¼-wavelength may be series tuned to resonance, and will exhibit two desirable characteristics: The radiation resistance of the extended whip antenna is raised to a higher value than that of a ¼-wavelength whip, providing a better match for the coaxial feed system, and the radiating characteristics of the antenna are improved slightly with a resulting increase in gain of the antenna. This is a result of the lowering of the radiation lobe of the whip antenna due to the increased length, and also because the high current area of the antenna is farther removed from the body of the car. The over-all length of the 10-meter extended whip should be 10 feet for 52-ohm coaxial feed, and 11 feet for 72-ohm feed. The whip should be series tuned at the base by means of a variable condenser *(Fig. 14).* The condenser, *C,* should be adjusted so as to grid-dip the antenna at the chosen operating frequency in the 10-meter band. The whip antenna will provide a very close match to the two feed lines if the above lengths are used, the VSWR will be very low, and the antenna will readily accept power over the whole 10-meter band.

15 and 20 Meter Mobile Antennas

A fifteen-meter ¼-wave whip antenna is approximately 11 feet long. It may also be operated on 10 meters, by the use of a series capacitor at the base as described above, thus providing excellent two band coverage (see *Fig. 15).* If a shorter whip is desired, a 10-meter whip about 8 feet long may be used, with some means of loading. Center loading is recommended, and for a standard two piece whip with a center loading form, 16 turns of No. 14 enamelled wire, 1″ diameter, and spaced to a winding length of 5¼″ will resonate the whip to the vicinity of the 21-Mc band. The whip may be adjusted to exact frequency by adjustment of the spacing of the turns of the coil.

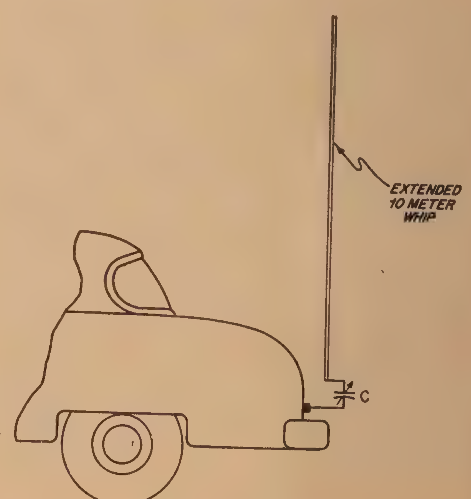

Fig. 14. Series resonating an extended 10-meter whip antenna.

An eight-foot whip may be loaded to 20 meters by the use of a small loading coil in the center of the antenna. A typical coil consists of 33 turns of No. 14 enamelled wire, 1″ diameter, and spaced to a length of 5¼″.

The loading coils for the 15 and 20-meter antennas should be wound on low loss polystyrene coil forms. Such a form is shown in *Fig. 16.* For high power, No. 10 enamelled wire should be substituted for the specified No. 14. The radiation resistance of a center loaded 15-meter whip runs about 28 ohms, while the radiation resistance of a center loaded 20-meter whip runs about 18 ohms.

40 and 80 Meter Mobile Antennas

At a frequency of 40 meters, the loading coil in the usual eight-foot mobile whip starts to

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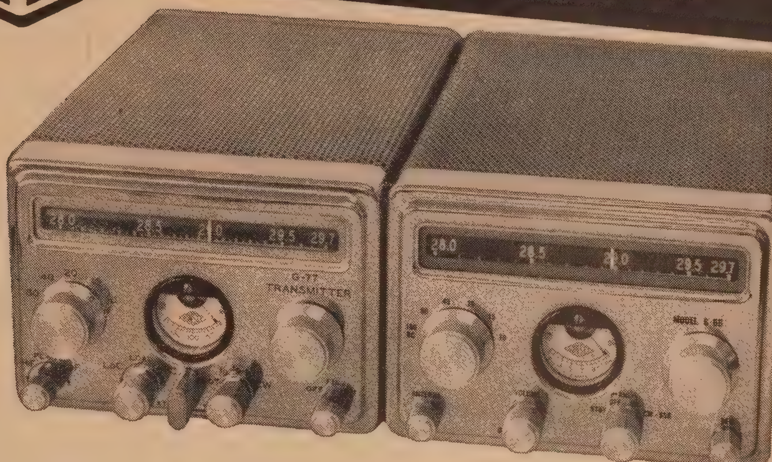

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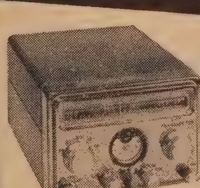

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assume a dominant role in the efficiency of the antenna system. At higher frequencies, the amount of loading needed is quite small, and the loading coil has few turns and relatively high efficiency. The losses are low, and the antennas are very efficient. At 40 meters, the loading coil is quite large and the losses are apt to be high, unless certain precautions are taken. *Coil 1* of *Figure 17* is an example of a high efficiency loading coil for 40 meters.

The radiation resistance of a 40-meter loaded whip is quite low, running in the vicinity of 10 ohms. Center loading should be used with the whip antenna.

Low Frequency Loading Coils

The literature on the design of high-Q coils discloses some interesting facts, not all of them favorable to the specialized coil required in a loaded antenna:

1. In general, the larger the coil, assuming a good form factor, the higher the Q.
2. Once the size of the form is established, the optimum wire size is somewhat smaller than the largest size that will give the necessary number of turns in the space available. In other words, use smaller wire and space the turns.
3. Reasonable liberties can be taken with form factor, and since a long slim coil can be more easily mounted on a car than a squat fat one, some departure from the dimensions can be tolerated.

As an experiment, W2CVV made several coil forms of dry maple, following these general specifications. The results were disappointing—the best coils wound on these forms had a Q of

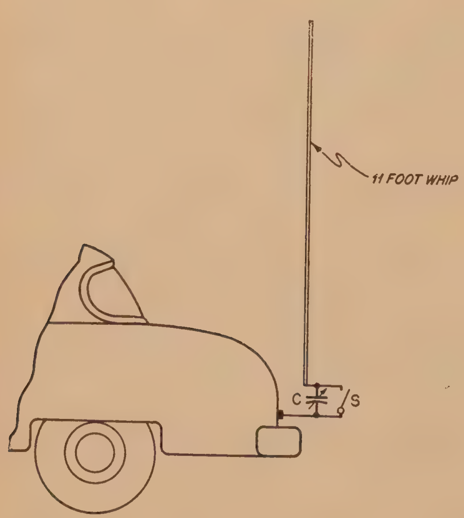

Fig. 15. The eleven foot whip antenna may be used for both the 10 and 15-meter bands. The whip is resonated at 10 meters by a series condenser and on 15 meters by shorting it out.

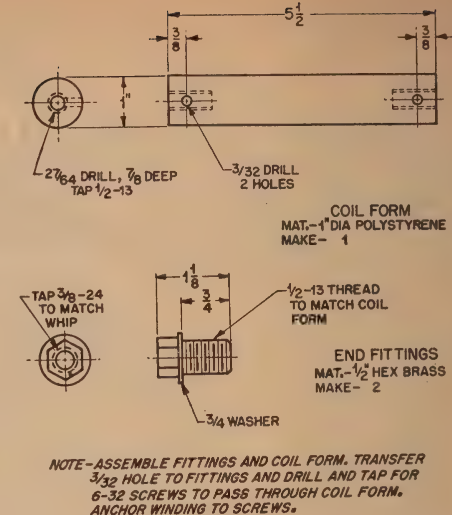

Fig. 16. Loading coil form suitable for use on 15 and 20 meters.

only 180. Although dry wood is supposed to have reasonably low loss, it was found that "reasonably low loss" was not good enough. Transferring one of the windings having a Q of 180 from the wood form to one of polystyrene immediately increased the Q to over 300.

A typical coil wound on a polystyrene form is shown in *Fig. 18,* and the constructional details are shown in *Fig. 19.* The core is a piece of 1¾″ diameter polystyrene rod, undercut and threaded to take the winding of No. 18 enamelled wire spaced 16 turns per inch. The end fittings are made from brass, and securely anchored to the core by threading into it and then staking with a No. 8 screw tapped through the brass washer and on into the polystyrene. The fittings are threaded to accommodate the antenna sections that will be used. After final adjustment, the entire coil is covered by a polystyrene sleeve, 1¾″ inside diameter, slipped on and cemented into place. Be sure to do a careful job of cementing since otherwise the coil will "breathe" and water will condense inside.

High Efficiency Loading Coils

Several types of highly efficient loading coils for 40 and 80 meters, designed and built by W6LXA are illustrated in *Fig. 17.* The core, or supporting structure of the coil is a 1″ diameter length of hollow phenolic rod. Fittings are placed on each end of the rod to match standard whip sections.

Coil 1 is designed to resonate at 7.2 mcs. It consists of a short length of *Barker and Williamson* airwound coil *No. 3906* or *Air Dux No. 2008* (2½″ diameter, No. 14 wire, 8 turns per inch). This airwound coil is spaced away

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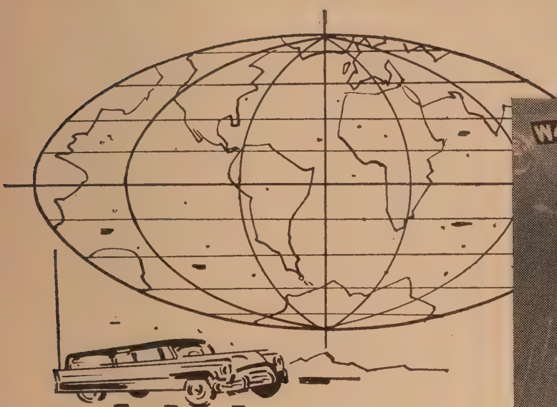

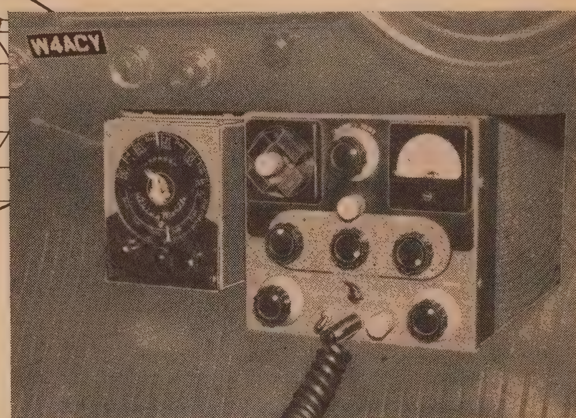

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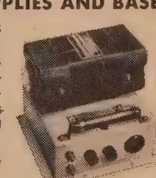

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from the phenolic rod by three polystyrene washers, one at each end of the coil, and one in the middle. This assembly provides a very rugged loading coil that will withstand hard abuse. It will handle 1000 watts of power at 7 megacycles with very little loss. The *Q* of this coil is 250.

Coils 2 and *3* are designed for 80 meters, and are built in the same manner as *Coil 1*. *Coil 2* uses *B & W. 3906* or *Air Dux No. 2008* air-wound coil material (*Q* : 350), while *Coil 3* uses *B. & W. 3907* or *Air Dux No. 1610* (2″ diameter) coil material (*Q* : 315).

Coil 4 is an experimental coil that has produced exceptionally good results. The theory of operation is discussed below. The center support of the coil is a 20″ length of hollow phenolic rod. The coil is 1½″ in diameter, and spaced away from the rod by three long strips of ¼″ x ¼″ polystyrene that run the length of the coil. These strips are spaced 120 degrees around the phenolic form. The coil is air-wound of No. 16 wire, 9 turns to the inch. The coil is 17¼″ long, and has 155 turns.

The *Q* of this coil (240) is not as good as the shorter, larger diameter coils, but its other properties greatly outweigh the importance of the lowered *Q*.

Coil 4 of *Fig 17* was wound with a rather unusual idea in mind. The coil was made small in diameter, and very long. This, of course, spoiled the form factor and resulted in a decided drop in the *Q* of the coil. It was hoped that the actual *radiation* of r-f energy from the coil would be enough to overcome the lowered efficiency of the coil.

The Radiating Loading Coil

This theory was borne out in actual field strength measurements. The long, thin coil repeatedly gave higher field strength measurements than shorter coils of better form factor and higher *Q*. This would indicate that the coil is actually radiating energy in conjunction with the whip. The radiation resistance of this antenna is also appreciably higher than that of antennas using more conventional loading coils. Using such a coil as illustrated in *Fig. 17*, a transmitting impedance of 17 ohms was measured for an eight-foot whip at 4 Mc., and a calculated over-all efficiency of 60% was obtained for the antenna system.

Capacity "Hats"

If a longer whip section is used above the loading coil, a greater total value of current

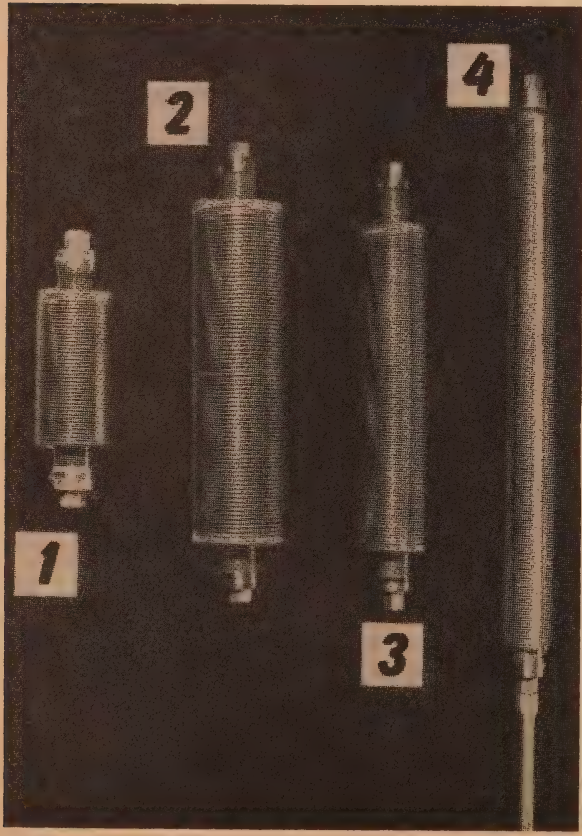

Fig. 17. High efficiency loading coils. Coil 1 is designed for the 40-meter band and is 2½ inches in diameter and 5 inches long. Coil 2 is a 75-meter loading coil made from B.&W. coil stock mounted on a one-inch phenolic rod. The coil is spaced away from the rod by polystyrene washers. Coil 3 is also a 75-meter loading coil with a two-inch diameter. Coil 4 is adjustable through the whip section at the end. It is designed for 75 meters and is 1½ inches in diameter.

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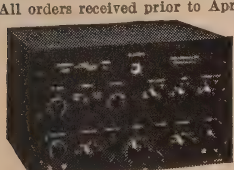

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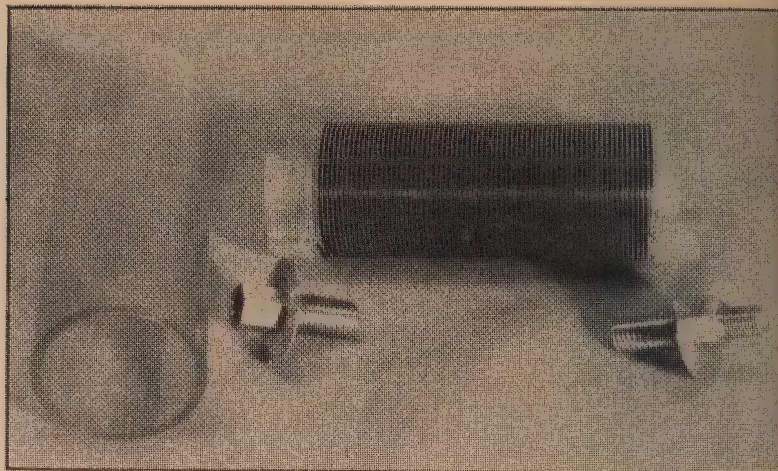

Fig. 18. The late W2CVV designed this polystyrene coil form in an effort to secure a maximum Q.

will flow through the loading coil and the lower section of the antenna. Since the whip is longer, the loading coil can be made smaller, with less inherent losses. A whip length above the loading coil of six feet is just about the practical maximum for ordinary automobile driving. An electrical length greater than this can be obtained by the use of a top loading disc, or capacity "hat" *(Fig. 20)*. This hat increases the effective capacity of the top section of the whip to ground and effectively "lengthens" the top section of the antenna. For best results this hat should *not* be located directly above the loading coil, as the capacity of the hat will then appear across the loading coil, rather than from the hat to ground. At all times, the capacity across the loading coil should be kept as low as possible. This rules out the use of metal coil cans or hats mounted in the vicinity of the coil. They will merely increase the distributed capacity across the coil, and do little to increase the efficiency of the antenna system.

160-Meter Loading Coils

The 160-meter band is rapidly gaining in popularity as a mobile band. The attenuation of vertically polarized signals in the 80-meter region during daylight hours is very pronounced (see *Fig. 21)* while, during the evening hours, the heavy QRM on the 80-meter band makes mobile operation very difficult.

The ground wave propagation characteristics of 160 meters is considerably better than that observed around 4 Mc. at any given distance. Contrary to some popular opinion, a loaded 8-ft. whip antenna can be made to work out on this band.

A 160-meter loading coil is shown in *Fig. 22*. Two different types are shown. Either one will work satisfactorily, and the choice between the two can probably be made on the basis of available materials.

Summary

In general, the following rules should apply to the over-all design of the loaded whip antenna:

Rule 1—For greatest coupling efficiency and highest radiation resistance, the loading coil of a whip antenna should be mounted as far up the whip as is physically possible.

Rule 2—If the loading coil is mounted more than half way up the whip antenna, some form of capacity top loading should be used.

Rule 3—The portion of the antenna above the loading coil should exhibit a minimum of shunt capacity across the coil. This means that any capacity loading device should be mounted at least a foot above the loading coil.

Rule 4—It is better practice to increase the length of the whip above the coil than it is to use lumped capacity loading. This will produce a minimum of shunt capacity across the loading coil.

Rule 5—The diameter of the loaded whip antenna should be as great as physically possible.

Operation of Low Frequency Loaded Whip Antennas

One of the penalties that must be paid for high Q and high efficiency in the antenna system is that the tuning of the antenna becomes extremely sharp. It is thus necessary to adjust the loading accurately, and to adjust it for each significant change in operating frequency. To put this in practical terms, if the frequency is shifted plus or minus 5 kc. without reloading, no appreciable loss will result; 10 kc. and the output and transmitter plate current will start to drop off; 15 or 20 kc., and the performance will seriously suffer. Obviously some convenient means must be provided for adjusting the antenna loading or some other portion of the circuit to tune out the antenna reactance at each frequency setting.

On 40 meters, the loading coil is smaller, and the whip is longer in proportion to the wavelength. Changes in frequency of plus or minus

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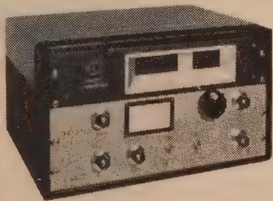

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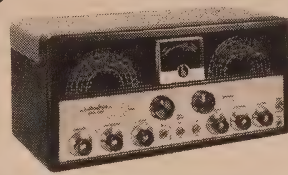

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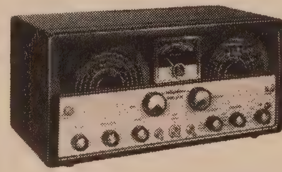

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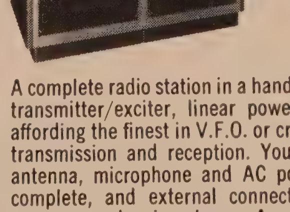

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30 kilocycles of the operating frequency may be made with no appreciable loss of antenna circuit efficiency. However, for changes of the order of 50 to 100 kilocycles, some means of varying the antenna loading must be incorporated in the antenna system.

Maintaining Antenna Resonance

On 10, 15 and 20 meters, the whip antenna will easily tune the complete amateur band with little trouble. No external means of altering the electrical length of the antenna is necessary. On 40 meters, the loaded whip antenna will tune over about half the phone band, but some means of varying the loading inductance is necessary if the complete phone band is to be covered in an efficient manner. On 80 meters, the effective band width of a loaded whip is very narrow, and some means of rapidly and conveniently retuning the antenna to resonance from the car should be employed.

The antenna resonant frequency may be changed either by altering the length of the antenna whip, or by varying the inductance of the loading coil. The first method is practically an impossibility to accomplish by remote control. A whip adjuster, such as shown in *Fig. 17* may be placed between the loading coil and the top whip section to allow an adjustment of four inches or so in the whip length, but the car must be stopped and the length change made by hand.

The antenna resonant frequency may be remotely adjusted, as shown in *Fig. 23,* by employing only partial loading in the antenna itself, and then by making up the difference with a variable inductor mounted in the car trunk.

A rotary inductance coil, such as the *Barker and Williamson No. 3852* is ideal for this purpose since it may be easily controlled from the operator's position by means of a flexible tuning shaft. *(Fig. 23).*

Referring to *Fig. 24,* the inductance of *L2* should be made as small as possible to keep as much of the antenna system outside the car as possible. This will reduce losses in the internal inductor, and at the same time will keep most of the lower impedance, or highest current portion of the antenna system out in the clear where it has a better chance to radiate. *L1* should be adjusted so that resonance is realized at the highest frequency to be used when *L2* is set for minimum inductance. In order to preserve the *Q* of *L2,* the tap should be connected so that the unused turns are not short circuited.

Initial tuning may be accomplished through the use of a grid dip oscillator, the base of the whip antenna being shorted to ground during the measurement. All adjustments should be made with the trunk lid closed.

As the inductance of *L2* is increased, the resonant frequency of the antenna system will be lowered. The additional losses introduced into the circuit by the base loading coil may be considered negligible when compared to the advantage gained by always having the antenna tuned to resonance.

An important requisite for this as well as for any other mobile antenna installation is that the car body be made as good a ground system as possible. To do this, all sections of the body should be bonded together. The bumpers, fenders, chassis, motor, etc. should be all bonded with flexible copper braid.

If the antenna is mounted at a place which requires a lead to be run between it and the inside of the trunk, a low capacity ceramic insulator should be used at the feed-through point.

With this method of tuning, *L2* should be mounted well clear of the car body to keep the shunt capacity low. If the variable tuning capacitor is used, *L2* may be mounted outside the car body at the base of the antenna.

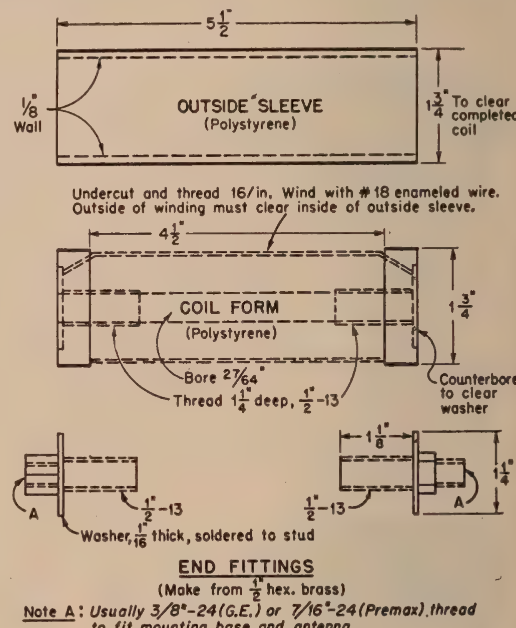

Fig. 19. Construction details of the loading coil shown in photograph above.

A gear reduction drive, such as the *Millen No. 10,000* should be used between the rotary inductor and the flexible shaft.

Mechanical Aspects of Mobile Antennas

Impact strength of the system is important. This is particularly so if you are inclined to go around crashing into trees and the like. This calls for intelligent compromise. When the system is strengthened the weight goes up. When the weight and mass goes up, so does the wind resistance and inertia. You can meet yourself

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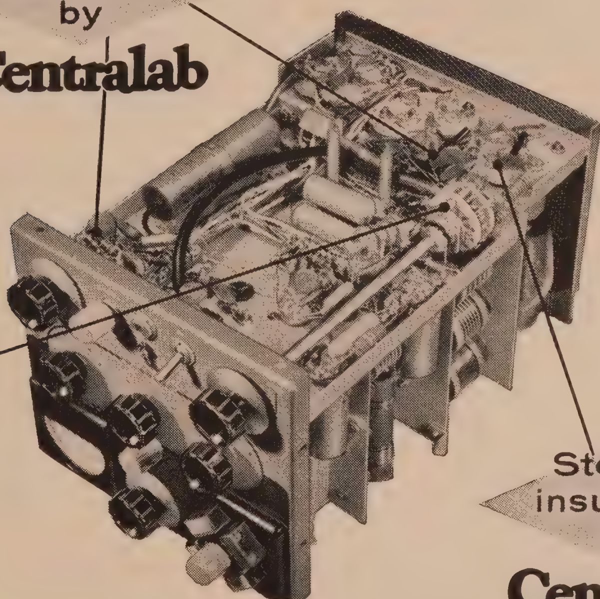

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coming back in this program. There are those who have attempted "beefing up" an antenna to a point where crashing into bridges and trees at any speed would leave the antenna intact. Doubling vehicle speed squares the force of impact. The "beefing up" process can be carried to a point where, under impact, the antenna will remain on the fender to which it is attached, but the fender will come off the car. This, too, is the wrong approach.

Rigidity

Electrical considerations demand that the vertical be just that. It must be vertical. It must remain perpendicular to the ground, and the vehicle, at all times, and at all speeds. When

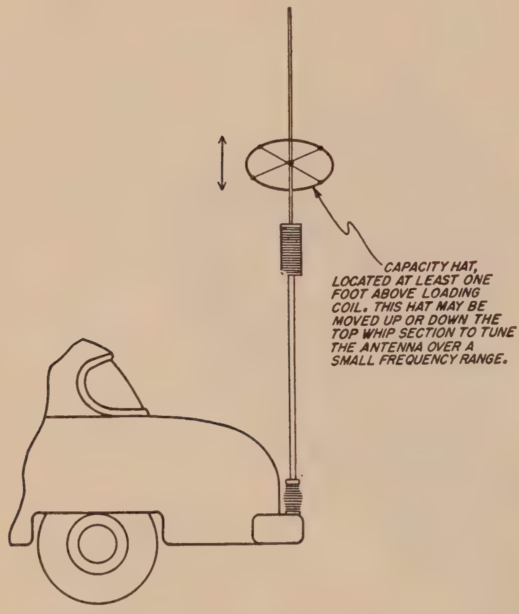

Fig. 20. Use of a capacity "loading hat." The "hat" is made of one-sixteenth inch diameter steel rods with four or six spokes. The diameter is between 8 and 14 inches and the hat is locked into place with "Allen" set screws.

it fails to do so, many undesirable things happen. The most noticeable of these is the changing of power input. Detuning, sometimes rapid in form, introduces reactance, shifting terminal impedance, increased transmission line SWR, fading of the signal, and the losses begin to mount. Absolutely no swing and sway, lean, wobble, or floundering around can be tolerated if you want to get the most for the least from your mobile antenna.

So now we know that we must make the thing stand straight up in the air. The only question is how to accomplish this. They do this sort of thing daily in the aviation industry not by "beefing up" and increasing weight and

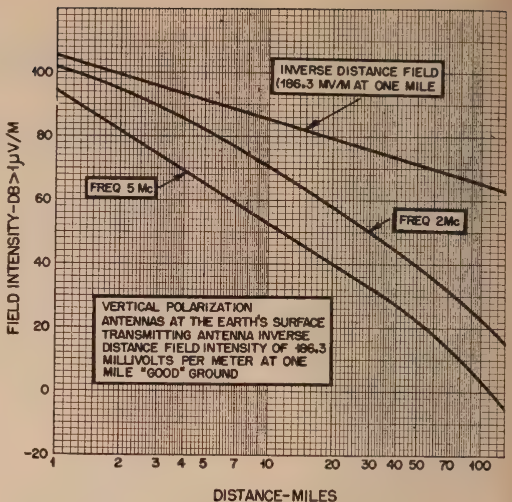

Fig. 21. This graph shows a comparison of field strengths over good ground for frequencies equivalent to the 160 and 80 meter bands. Note that at 10 miles the 160 meter field is approximately 10 db. stronger than the 80-meter field.

wind resistance, but by slimming down, using lighter materials, and by reinforcing only at strategic points. The place to start is at the base mount. This should be substantial and should be rigidly attached. It should also be adequately reinforced. Any motion at this point is multiplied many times at the corona ball. If you have a late model car, do not lean too hard against the fender while installing the base mount. The sheet metal now being used by car manufacturers is so thin you may fall through. Back up the base mount, behind the fender, with sufficiently substantial reinforcing to positively eliminate excessive flexing and sway.

Springs

The use of a spring in a mobile antenna is highly detrimental. Nothing will cause more loss, or electrical difficulty, than a spring, any spring, any kind, anywhere in the antenna, any time. The easiest way to reduce the effectiveness of your 50 watts to the level of a fair 15-watter is to use a spring. It is obviously not possible to keep the antenna perpendicular when one is used. A little wind resistance will cause the antenna to "lean." When you accelerate, decelerate, apply the brakes, or take a curve, the antenna will flounder around. Springs also "age," sometimes introduce varying amounts of inductance, and add to the loss resistance. They offer no protection against impact unless you happen to be moving slowly. They can destroy all you can otherwise gain by improvement. Take your choice. Either have a spring or an antenna. You cannot have both.

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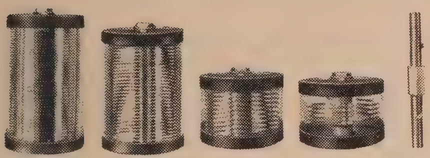

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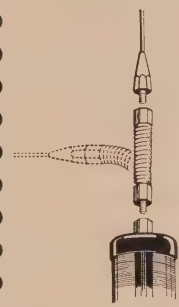

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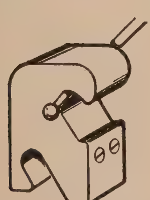

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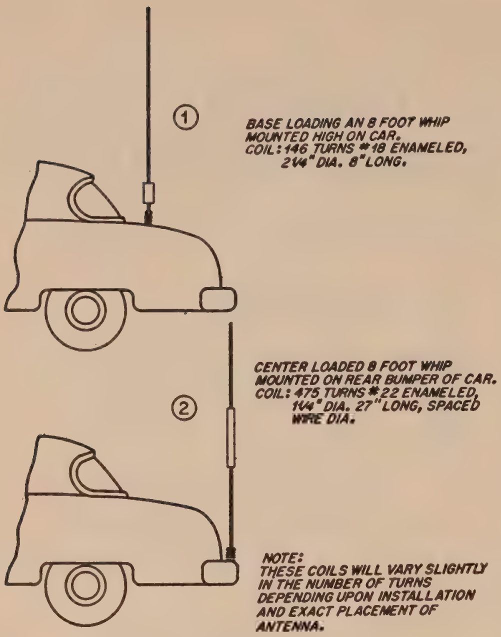


Fig. 22. Two variations of a 160-meter loading coil. Either method of loading may be used with assured equivalent results.

Position on Car

Before going on up the antenna, we should at this point establish the best location on the car to install the base. We have some latitude in this decision but it will be controlled somewhat by the type and design of the car, the type of equipment installed in the car, distance from the equipment to the antenna, your personal desire, and last but by no means least, the XYL's commands. If you really want that additional 3 db. you had better sell her first. That is, sell her on the idea. The rest is easy. It has been well established that, at least for 10-meter operation, the best location is on the left front fender a foot or so ahead of the car windshield. It has also been fairly well established that this same location is best for operation in the lower frequency bands. It has other advantages. It allows the use of a short transmission line, proper base elevation above ground, and the possibility of keeping the antenna clear of car structure and body contours. The next best location is on the rear deck, above the trunk lid, and on the left side of the car. This also provides proper base elevation. The first location is the only good location if you have a station wagon.

Height of Elements

In any case the base mount should be installed at an elevation of about 36″ from the ground. Unless you have mighty high bumpers this eliminates bumper mounts. The elimination of bumper mounting also eliminates much undesirable antenna directivity and pattern distortion. By mounting the base at the 36″ level, using a 36″ standard base support rod, a loading coil, and a standard 60″ top whiprod the coil is about halfway up the antenna from ground and is where it should be electrically. As mentioned earlier we are looking for the best possible compromise and this is it.

Re-inforcement

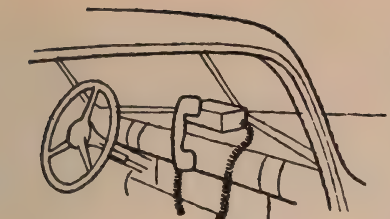
It has been stated earlier that the base mount should be adequately backed up with substantial reinforcing. Not only is this essential from a structural standpoint, but it is also necessary in order that a good low resistance ground termination may be had. The sheet metal sections of a car are rarely bonded together electrically in a manner providing good low resistance continuity. This backing plate therefore, serves two purposes. It supports the base mount so that sway of the antenna is eliminated and it also aids in fixing an adequate ground of low resistance. It should be bonded directly to the car frame with heavy braid or flexible cable. The necessity for doing this cannot be emphasized too strongly.

Base mounts with coax terminations built in are attractive, but should be chosen with care. They are a source of trouble in that through constant motion and vibration, they can work loose and cause intermittent operation. When this occurs, they begin to build up high resistance through contact corrosion, and losses skyrocket. If, for some reason, they must be used, it is suggested that they be modified to include a machined insulating tube around the female connector capable of furnishing constant pressure, thus prolonging the period of usefulness before the two parts loosen and corrode. There is no substitute for a well-soldered connection.

Building An "All-Band" Loading Coil

This "all-band" coil was designed for use in a base-loaded mobile antenna with a minimum over-all length of six feet. It will resonate an antenna of this length to any frequency between approximately 3.75 Mc. and 30 Mc. Using a longer whip or adding a capacity hat to the antenna will permit operation on still lower frequencies.

The continuously adjustable feature is valuable in emergency or portable operation. The car may be parked and a long wire antenna clipped to the end of the mobile antenna. Then the entire combination may be resonated to the operating frequency by means of the slider in the loading coil, resulting in an antenna that may often rival the single-band whips in efficiency.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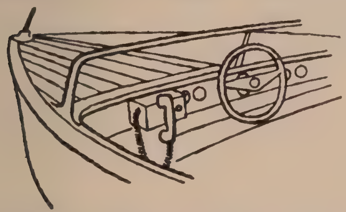
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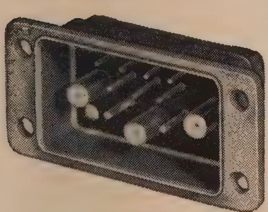
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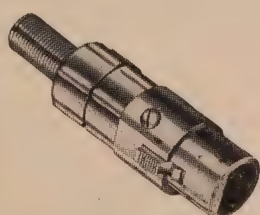
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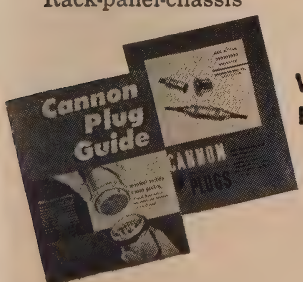

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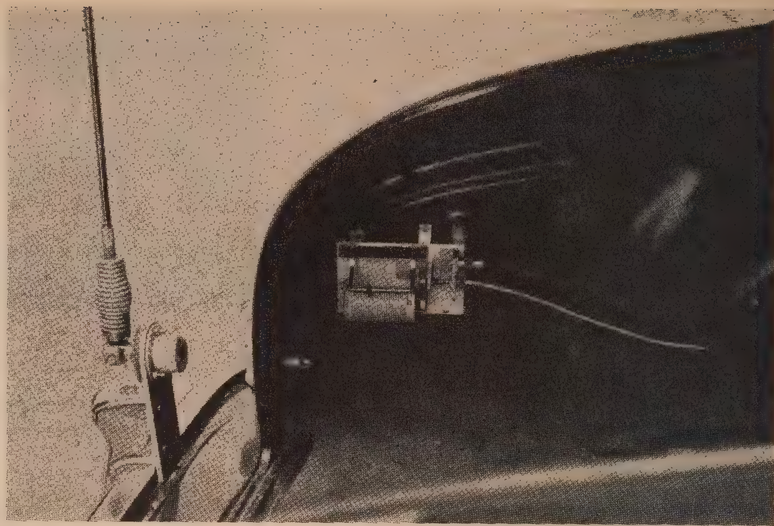

Fig. 23. Partial base loading is used by W2AEF to obtain maximum coverage with an 80-meter loaded whip. The variable loading coil was made from the antenna coil of an SCR-274N command transmitter. It may be replaced with a B.&W. #3852 variable inductance.

Figure 25 illustrates the constructional details of the loading coil. The fiber-glass rod that carries the weight of the antenna may be obtained from a sporting-goods store in the form of a "glass" fishing-rod blank. Obtain a fairly husky one and cut the piece required from the large end. Damaged blanks can frequently be picked up from larger sporting goods stores, where fishing rods are repaired, almost for the asking.

The necessary plastic may be obtained from plastic extruding firms or specialty shops. It should preferably be one of the new butyrates that resist shattering and do not deteriorate under exposure to weather and sunlight. Some amateurs, who have built similar coils, have utilized plastic household utensils as a source of this material.

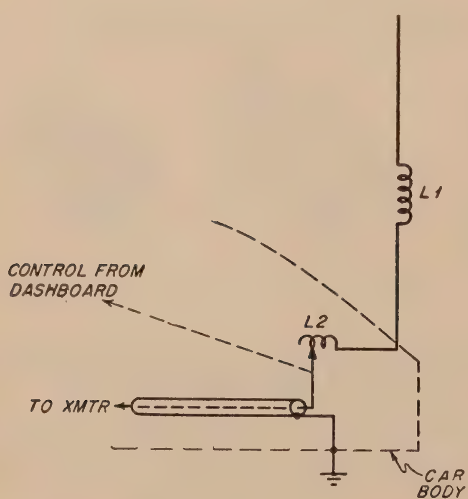

Fig. 24. Electrical equivalent of the variable loading idea shown in Fig. 23.

Construction

Start construction with the plastic end pieces (*B,C*). One of several possible methods of making them is described here. Cut two discs, three inches in diameter, from 3/16-inch or ¼-inch plastic. Then, cut two more discs of a diameter just sufficient to fit inside the ends of the *B&W* coil (*A*). Cement them to the centers of the larger discs. Drill a hole through the center of each end piece, to pass the fiber-glass rod (*D*).

Place these end pieces on the ends of the coil and measure the exact overall length. Cut the fiber-glass center rod one inch longer.

Now make the metal fittings (*E* and *F*). They may be of brass or aluminum and are about ¾″ in diameter and 1″ long. Drill half way through them from one end and tap the hole for ⅜″ x 24 threads to match standard mobile antenna fittings.

Drill a hole through from the other end to be a tight fit on the fiber-glass rod. Drill and tap holes in the fittings for an *8-32* set screw to fasten them to the rods. Alternately, a small hole may be drilled through the fittings and rod to accommodate a brass drive pin.

Next, make the slider mechanism (*G, H, I*). Obtain a piece of brass or aluminum about ⅜″ x ½″ x ¾″. Cut a groove lengthwise along one of the ⅜″ x ½″ sides to fit the contour of the center rod. This may be done with a file or by drilling a hole of the proper diameter in a piece of metal somewhat longer than desired and sawing it in two, lengthwise through the hole.

Drill a ¼-inch hole into the bottom of the block, ½″ from the groove for the brass adjusting rod (*J*), which should be about a foot long. Drill and tap a hole for a set screw to hold the rod to the block.

The contactor (*H*) can be formed from a

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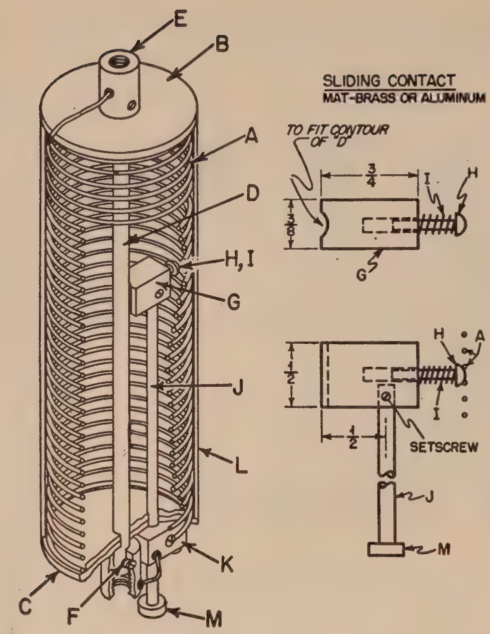

Fig. 25. Details of the "all-band" loading coil described in text. A—B&W, No.-3906-1, bulk loading coil consisting of #14 tinned copper wire spaced wire diameter, 2½ inches in diameter, ten inches long. B, C—Three-inch diameter plastic discs, ⅛ or ⅜-inch thick, to which are cemented smaller discs to fit inside ends of A. D—Fiberglass rod, approximately ⅜ inches in diameter x 11½ to 12 inches long. E, F—¾ x 1-inch brass or aluminum, drilled and tapped as described in text, G—¾ x ⅜ x ½-inch, aluminum or brass block, modified as shown. H—brass contact pin. I—small coil spring. J—12 x ¼-inch brass rod. K—¼-inch shaft lock (Millen No. 10063). L—Outside plastic coil shield. M—Knob for adjusting rod.

round-head brass screw or pin. It is held in a small hole in the face of the sliding block (G). The contactor is spring loaded by slipping a small coil spring over its shaft before inserting it into the hole.

Drill a hole through the bottom disc (C) to accommodate the adjustment rod. Fasten a *Millen 10063* shaft lock (K) to the disc in alignment with the hole. At this time, drill a few additional holes in the disc to allow moisture to escape from the completed loading coil.

Before assembling the various components, cement a narrow strip of thin plastic parallel to one of the ribs on the coil (A) about ⅜″ from it. The contactor (H) will ride between these strips. Be sure that the turns between them are clean and free of cement.

Assemble the various parts as shown in *Fig. 25*, connecting the top of the coil to the top fitting (E). The other connection is made between the shaft lock (K) and the bottom fitting (F). Complete the job by cementing a thin wrap of plastic around the coil to the end discs.

Mounting the Coil

Although the coil is designed for base loading, it should be mounted at least a foot from the bottom of the whip. This position permits pulling the adjustable slider clear out when operating on the lower frequencies. Equally important, this is a very high-Q coil, and any large metal mass in its field will reduce its Q sharply. For this reason, too, the coil should be mounted well clear of the metal body of the car.

Tuning the Antenna

When the coil has been completed and installed on the antenna, the resonant frequency of the system may be found by coupling a grid-dip oscillator to the antenna by means of a two turn link inserted between the base of the antenna and the frame of the car. When the resonant points are found for each band, the correct placement of the slider rod may be marked with spots of nail polish.

The mobile whip mount is often clamped to the rear bumper of the automobile. Such a mounting requires no addtiional holes drilled in the body of the car.

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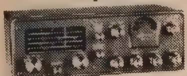

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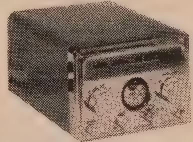

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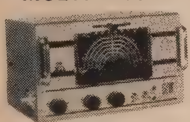

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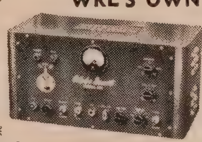

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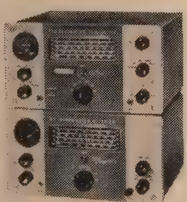

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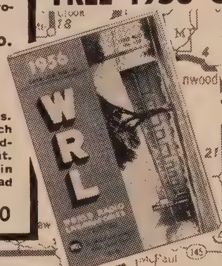

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Chapter Eight

Mobile Test Equipment


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Mobile Test Equipment

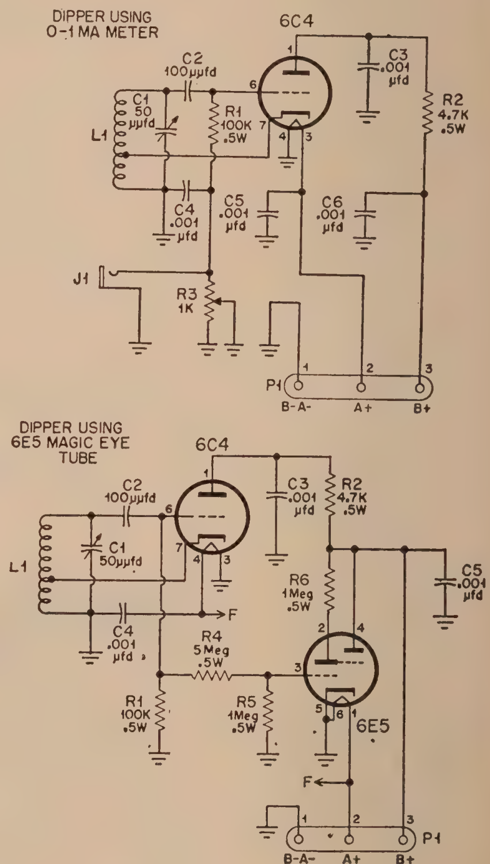
Certain pieces of test equipment are an absolute necessity for efficient mobile operation. Others are handy auxiliary aids that make mobile operation a pleasure, rather than a frustrating experience. The purpose of this chapter is to describe pieces of test equipment that are eminently suited to mobile work, and to show how they may be used in the most effective manner.

the Grid Dip Oscillator

The grid dip oscillator, or "grid dipper" is a calibrated, low power oscillator equipped with a meter which indicates the oscillator activity. When this oscillator is coupled to a circuit which is capable of absorbing r-f power from the oscillator, the activity of the oscillator will decrease. If the load circuit is tuned, it will accept power more readily at the particular frequency where it is resonant. If the grid dipper is coupled to a non-resonant type of load (such as a low inductance link feeding a pure resistance) power will be accepted by the load over a wide range of frequencies, and the effect on the oscillator will be a general reduction of the meter reading of the dipper regardless of the frequency to which the grid dipper is tuned. If, on the other hand, the grid dipper is coupled to a low-loss parallel tuned L/C circuit power will be absorbed most efficiently at the resonant frequency of the tuned load circuit, and a well defined dip in the oscillator grid current will be noted as the grid dipper is tuned across this frequency. The higher the *Q* of the coupled circuit, the sharper the dip will be.

Mobile whip antennas are high *Q* circuits, the loaded antennas for 80 and 40 meters having extremely high *Q*. To check the resonant frequencies of these high *Q* antennas using a grid dipper is an exacting task, since it is often hard to obtain a readable dip on the meter. For best results, the feedline should be removed from the antenna, and the base of the loaded whip should be grounded through a one-turn link coil, and the dipper closely coupled to this coil. A three-turn coil should be used for 80 meters. The dipper should be slowly tuned across the whip frequency, and the meter watched for a short, sharp kick as the resonant frequency is passed. The resonance frequency should be approached from both the high frequency and low frequency sides of resonance, as often the meter kick is more pronounced as resonance is approached from one particular side.

When the resonance point has been found, the coupling between the dipper and the link should be decreased until there is a barely discernible kick as the grid dipper is tuned through resonance. A series of resonance readings should now be made, logging the exact frequency of the dipper with the aid of a frequency meter or an accurately calibrated receiver. If ten accurate and separate readings are made, and the average of these readings taken, the resonance frequency of an 80-meter



C1—50 μμfd., Bud MC-1853.
C2—100 μμfd., silver mica.
C3, C4, C5, C6—0.001 μfd., ceramicon Erie 801-001.
J1—Jack, open circuit.
P1—Socket Cinch-Jones, S-303RP and plug P-303CCT.
R1—100,000 ohms, ½w.
R2—4700 ohms, ½w.
R3—1000-ohm potentiometer.
R4—5.0 megohms, ½w.
R5, R6—1.0 megohm, ½w.
Dial—National AM, scale #2.

Fig. 1. Two versions of a simple inexpensive grid dipper covering the range of 2.8 to 35 megacycles.

loaded whip can be read to about 5 kilocycles.

Since the average pass band of an 80-meter loaded whip is of the order of perhaps 20 kilocycles, it can be seen that great care should be taken when determining the frequency of the antenna by the use of a grid dip oscillator.

On the higher frequency bands the problem is less acute. The *Q* of the antenna system is lower, the whip has a broader frequency response and the grid dipper will therefore indicate a broader, easier to read null.

Construction of a Simple Grid Dip Oscillator

A simple, inexpensive grid dipper is illustrated in *Fig. 1.* This dipper covers the range of 2.8-35 Mc., covering all mobile frequencies up through the 10-meter band.

A single 6C4 is used as an electron coupled oscillator, using a 0-1 milliammeter in the grid circuit as a resonance indicator. A 6E5 electron eye tube may be used as an inexpensive substitute for the meter, if desired.

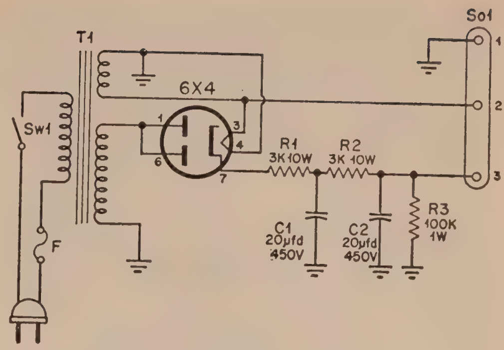
The grid dipper should be built up in a small shielded box *(Bud Minibox),* with the grid dipper coil socket mounted on the rear of the box on ½″ metal spacers. Spacing the coil away from the box in this way allows the coil of the dipper to be brought closer to the testing circuits before the box of the dipper gets in the way. The two leads from the coil to the grid and cathode of the 6C4 are brought through a ½″ hole drilled directly beneath the coil socket. The ground end of the coil is connected to the bolt that holds the coil socket.

C1 is mounted directly in front of the coil socket, and coupled to the *National AM* dial by means of a shaft coupler and a short length of ¼″ brass rod. The 6C4 tube socket is mounted in front of *C1,* on a small angle bracket cut from scrap aluminum. *Pin 4* of the 6C4 is grounded, and *C3* connects between *pins 1* and *4*. *C2* connects between *pin 6* and the stator of *C1,* and *R1* connects from *pin 6* of the 6C4 socket to an insulated tie point. *C4* connects from this tie point to the ground. *C5* connects from *pin 3* to *pin 4* of the socket. *R2* is attached to *pin 1,* and the opposite end goes to an insulated tie point.

Sensitivity control *R3* is mounted on the side of the box, as is *J1*. Any 0-1 ma. d-c meter may be plugged into *J1* to act as an indicating device. Condenser *C6* is mounted on the back of *P1*, from *pin 3* to *pin 1*. *Pin 1* is grounded.

The grid dipper requires 6.3 volts at 0.15 amperes a-c or d-c for the filament, and 90 to 250 volts d-c at 5 milliamperes for the plate supply. This power may be "borrowed" from the converter power receptacle on the car receiver, or a separate power supply, such as shown in *Fig. 2* may be used.

If a 6E5 electron eye tube is incorporated in the dipper, the filament drain is increased to 0.5 amperes. The plate current drain will then be 7 milliamperes.



C1—C2—dual 20/20 µfd.; Sprague TVA-2730.
F—fuse, 1 amp., 3AG.
R1, R2—3000 ohms, 10 watt, wirewound.
R3—100,000 ohms, 1w.
So1—Jones, socket, S303-RP.
Sw1—S.p.s.t. switch.
T1—120v. at 50 ma., 6.3v. at 2.0 amp., Merit P-3045.

Fig. 2. Power supply for the dipper shown in Fig. 1.

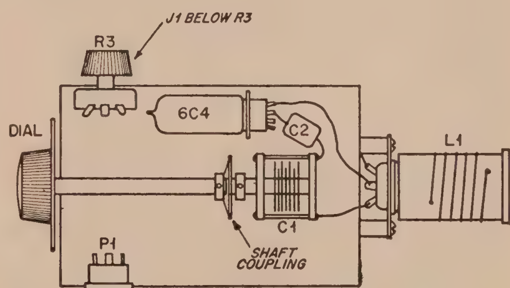
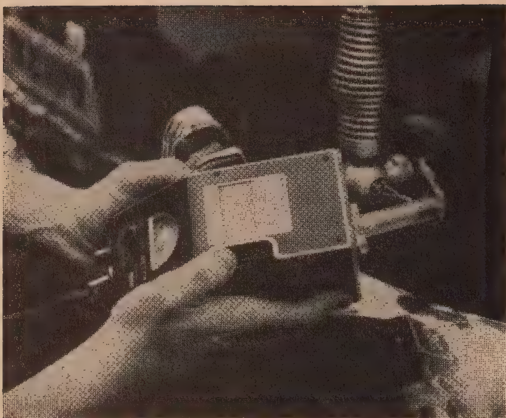


Fig. 3. Suggested mechanical layout of the inexpensive grid dipper described in the text.

COIL NO.	FREQUENCY RANGE	WINDING
1	2.8 - 4.9 Mc	34½ TURNS #35 DCC TAP 1½ TURNS FROM GROUND
2	4.6 - 8.0 Mc	21½ TURNS #24 E TAP 1 TURN FROM GROUND
3	7.6 - 13.2 Mc	13 TURNS #24 E TAP 1 TURN FROM GROUND
4	12.6 - 22 Mc	6¾ TURNS #22 E TAP ¾ TURN FROM GROUND
5	20 - 33 Mc	5 TURNS #22 E SPACED ½" OVERALL TAP ¾ TURN FROM GROUND

NOTE - ALL COILS WOUND ON 1⅜ DIA FORM (ICA #2158) ADJUST SPACING OF TURNS ON COIL 5 TO RESONATE AT 20 Mc WITH C1 FULLY MESHED

Coil Data for the circuits shown in Fig. 1.



This is the method of coupling a grid dipper to a mobile antenna to find the resonant point. Details on grid dipper utilization appeared in the January, 1953 issue of CQ.

A suggested mechanical layout for the dipper is shown in *Fig. 3*.

When the dipper is completed, it should be checked and calibrated against an accurate frequency meter or receiver.

For additional information on the general operation and use of grid dippers, refer to the January, 1953, issue of *CQ* Magazine.

the Antennascope

The *Antennascope,* designed by W2AEF and described in the June, 1954, issue of *CQ* Magazine, is a modified bridge circuit that will measure the resistive impedance of an antenna. It is invaluable in adjusting mobile whip antennas.

The *Antennascope* is connected between a suitable r-f source such as a grid dipper, and the antenna to be measured. One side of the r-f bridge of the *Antennascope* is a potentiometer that is calibrated in ohms. When the bridge is balanced, and this potentiometer is set for a null reading, the resonant frequency of the antenna may be determined from the grid dipper, and the radiation resistance of the antenna may be read directly from the calibrated potentiometer on the *Antennascope.*

As usual in bridge circuits, the variable element (*R1*) is adjusted until a zero null is obtained on the indicating device (detector). By means of the calibrated setting of *R1,* the value of the unknown element, *Rx,* is found. Since the ratio arms *R1, R2,* and *R3* are resistive elements, the unknown *Rx* must also be resistive, or non-reactive, before an accurate balance can be obtained. The configuration of this simple bridge is shown in *Figure 6*. The schematic of the Antennascope may be seen in *Figure 7*.

The impedance presented by any antenna is resistive only at resonance. The bridge in the Antennascope cannot be brought to balance until the r-f generator is tuned to the resonant frequency of the antenna under test. Thus, the Antennascope also provides a foolproof method of quickly and accurately determining the resonant point of any antenna. It is the working out of these two problems; i.e, radiation resistance and resonance, wherein the constructor will find the greatest value of the *Antennascope*.

The useful range of the *Antennascope* is from 5 through 500 ohms. In the original unit this was covered by a single scale which resulted in those readings below 100 ohms being crowded. In this new improved model two scales have been provided. A "high" scale (*R1a*) with readings of good visibility from 50 to 500 ohms. A "low" scale (*R1*) with good readings of from 10 to 100 ohms. Values between 0 and 10 ohms, and 500 to 1000 ohms may be read through the use of external resistors.

The *Antennascope* is designed to be used with a grid dipper as the r-f generating source.

Construction

In the wiring schematic of the *Antennascope* (*Fig. 7*) the only real critical components are *R1* and *R1a*. Crystal sensitivity is also important and is discussed later on in this text.

From an ideal aspect, *R1* and *R1a* should be perfect non-reactive resistors, thus *any-old-type* potentiometer of the proper value will not work in this spot. Each potentiometer that we have has been measured and has some internal inductance and capacitance. Too much of either of these items will seriously inhibit the use of the *Antennascope* on the higher frequencies.

The original model of the *Antennascope* employed a *Centralab Type M* composition potentiometer. Unfortunately, this control is not available on the general amateur market, although some companies have obtained a quantity on special orders. During the development of the *Antennascope* we tried dozens of substitutes to find a suitable replacement. The next best thing to the *Centralab* potentiometer

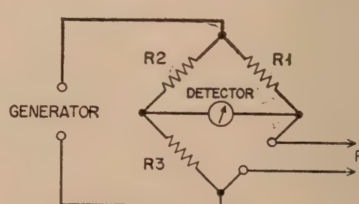


Fig. 6. Fundamental bridge circuit. This is the basic idea of the Antennascope-54. Balance of the bridge is indicated by a null, or zero reading on the meter.

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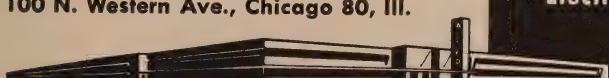

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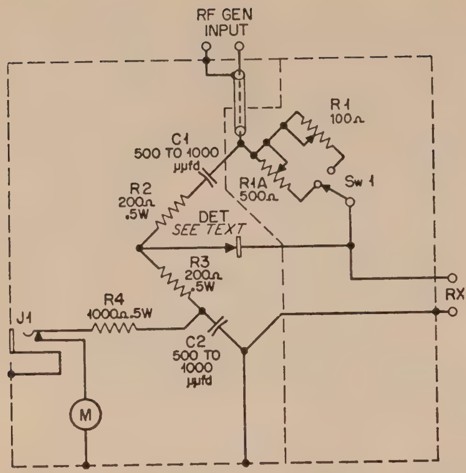


Fig. 7. Wiring schematic of the Antennascope-54. In this model a range switch, Sw1, has been added. A jack, J1, is placed in series with the meter: although it is essentially unnecessary. Some constructors will find it useful for making readings somewhat removed from the actual position of the instrument.

is the *Allen-Bradley Type J,* followed rather closely by the *Ohmite Type AB*. Either of these controls may be used for entirely satisfactory results within the useful frequency range of this instrument.

Before a potentiometer is soldered into this circuit it should be checked with an ohmmeter. Temporarily mount it with a scale so that the presence of backlash may be ascertained. Rotate the arm back and forth and note whether or not the identical ohmmeter readings occur at the same scale reading when approached from either clockwise or counterclockwise rotation. In some controls the carbon contact in the slider arm may be loose. It can be tightened by crimping the mounting clip.

The range switch, *Sw1,* which is a new feature in the *Antennascope,* must be of the small slide type. Toggle and wafer switches cannot be used here.

Resistors *R2* and *R3* must be identical values and although shown in *Fig. 7* as having a value of 200 ohms, they can be anything from 50 to 200 ohms—as long as they are identical. Another word of caution: Do not make the mistake of using the wire-wound resistor that physically look like their carbon brothers.

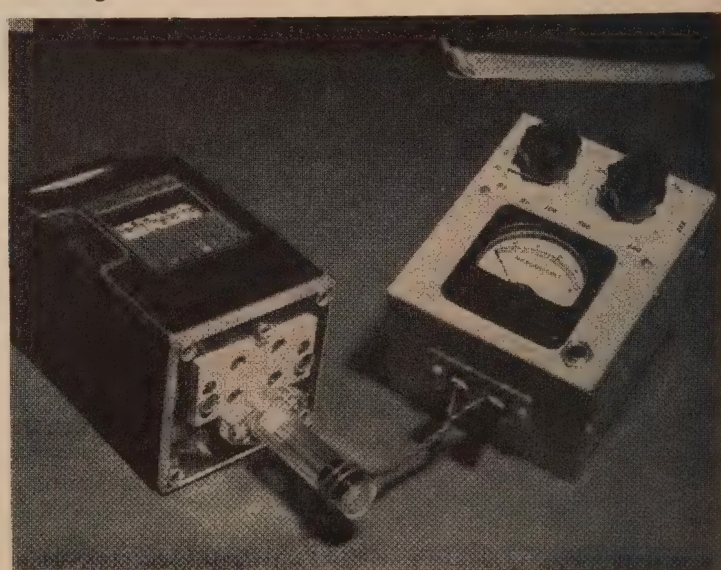
Condensers *C1* and *C2* must also be matched to identical values between 500 and 1000 μμfd. The button type ceramics (*Centralab ZA-751,* for example), are ideal for maintaining low inductance in their corresponding bridge arms. It is possible to use mica, disc or tubular ceramics in the *Antennascope* if the instrument will never be used above 30 Mc.

Crystal Diodes

The design of the original *Antennascope* was predicated on the use of the 1N23A diode. Since that time the stability and sensitivity of that diode have been improved (1N23B) and a greater number of crystal diodes are now on the market for use on UHF-TV. Some of these are cheaper than the 1N23 series, and have the additional facility of being easily mounted.

The comparative sensitivities of these diodes in the Antennascope circuit are as follows:

1N23B	100%	(Sylvania)
1N23A	95%	(Sylvania)
G7A	93%	(General Electric)
1N58	65%	(Sylvania)



The Antennascope is an important addition to every Ham station. It may be used to measure the resistive impedance of mobile antennas in the range of 5 to 500 ohms.

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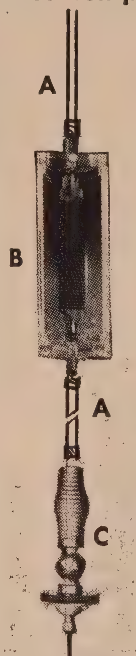

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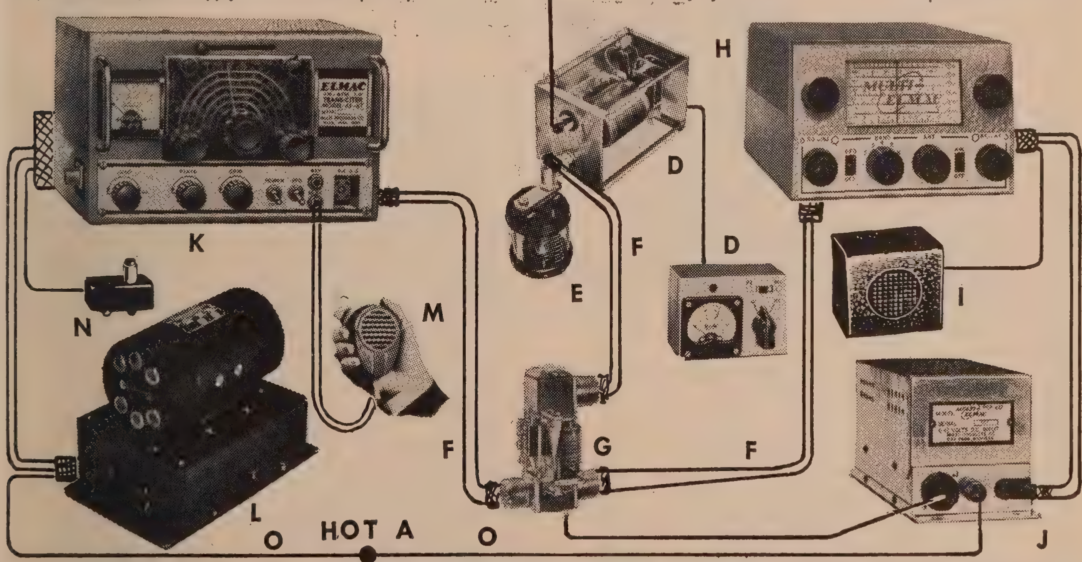

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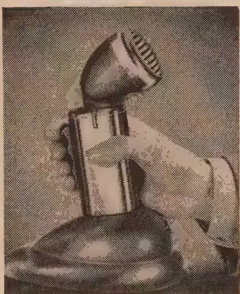

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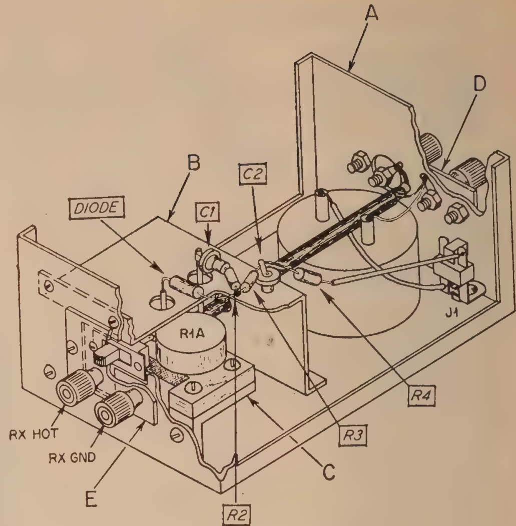


Fig. 9. Wiring view of the Antennascope-54. The layout should be followed as closely as possible.

Diode types 1N34 and CK 710 work poorly in this circuit.

Since the *Antennascope* is to be used with a very low power r-f source, such as a grid-dipper, the eventual sensitivity will also depend upon the meter used in the *Antennascope*. A full-scale movement of 200 micro-amperes is recommended, with an internal meter resistance of 1000 ohms.

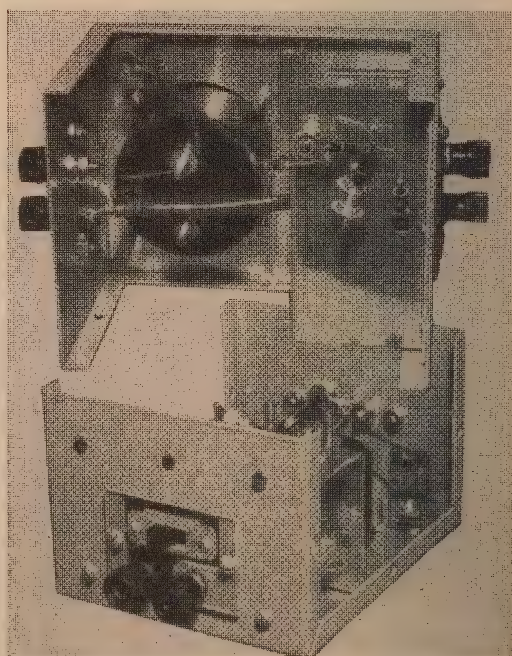


Photo views of the Antennascope-54.

Mechanical Details

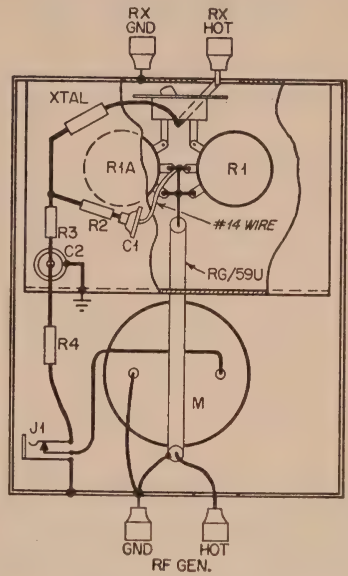
An "exploded" view of the *Antennascope* is seen in *Figure 9.* The unit is assembled in a *Bud CU-2105 Minibox* (3″x4″x5″). An inner shield and shelf (*B*) is folded and drilled out as shown in *Figure 10.* The *Minibox* is also drilled and cut out as shown in this drawing. Note the irregular cut-out in the left-hand view (*A*) which clears the binding posts (*Rx*) and the range switch, *Sw1*.

The terminals for *Rx* are mounted on a piece of lucite (see *part E* of *Figure 10*) which in turn is mounted over the cutout in the top of the *Minibox*. The range switch is also mounted here to reduce any stray capacitance effects between elements of the switch and the box.

Controls *R1* and *R1a* are then mounted directly under the *Rx* terminals on a ¼-inch thick piece of lucite. The insulating section is cut and drilled out as shown in *part C* of *Fig. 10.* The constructor must then drill two ¾-inch diameter holes in the front panel of the box to permit the shafts of *R1* and *R1a* to pass through *without* making contact with the box frame. Use extension couplings if the original shafts are not long enough.

The terminals for the r-f generator input are mounted at the bottom of the box. The "hot" lead is connected to a short length of RG59/U which passes through the hole in the inner shield. The other end of the coaxial cable goes directly to *R1* and *R1a*.

The connecting leads to the various components in the bridge arms must be made as short as possible to minimize inductance and to prevent stray coupling. Minimum lead



Wiring view and layout.

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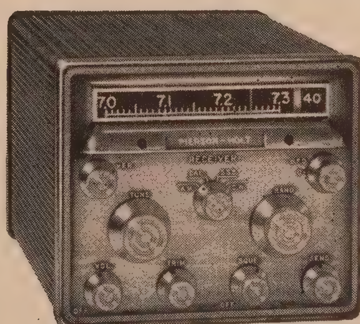

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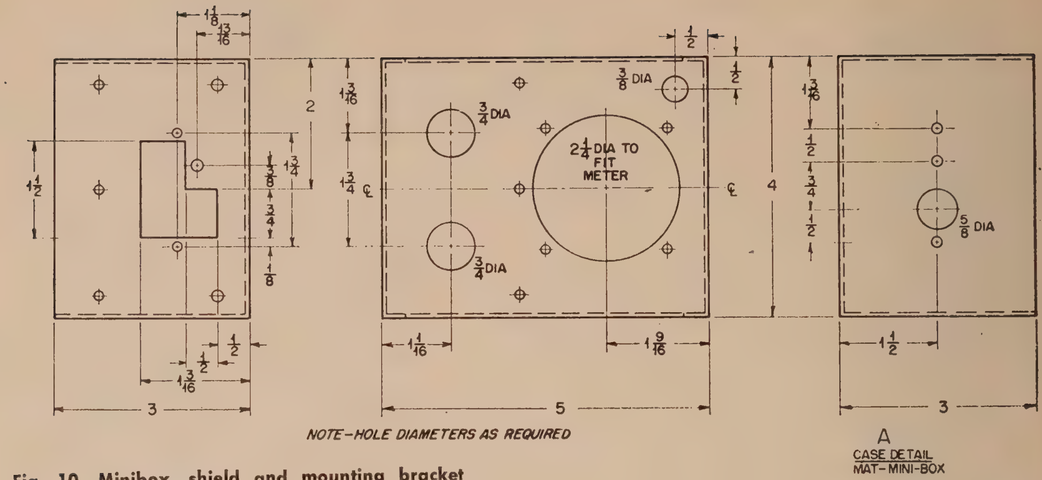


Fig. 10. Minibox, shield and mounting bracket layouts and drilling dimensions.

length is especially important for the connections between the potentiometers and the range switch, and between the "hot" *Rx* terminal and the switch. For these reasons, *R1* and *R1a* are positioned and mounted so that their terminals may be soldered almost directly to the switch tabs. The tab from the sliding arm of the switch is connected directly to a lug at the bottom of the hot *Rx* terminal.

The crystal diode shown in the unit in these photographs is a *G.E. G7A*. It is mounted in place with its own wire leads.

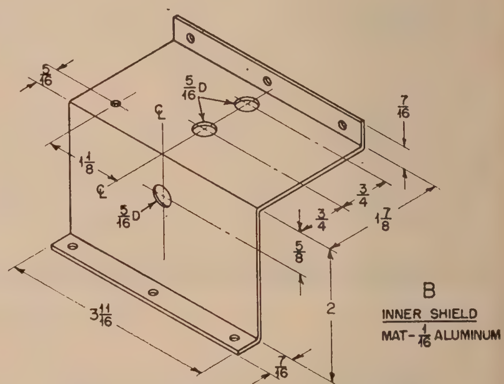
The various numbered figures and photographs in this article should clearly illustrate the wiring.

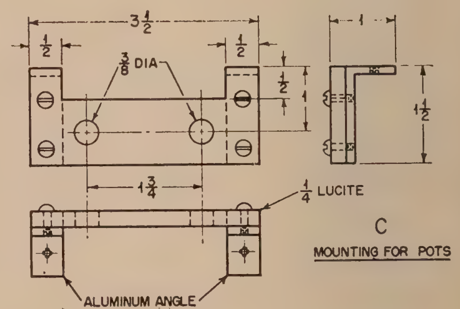
Calibration is Easy

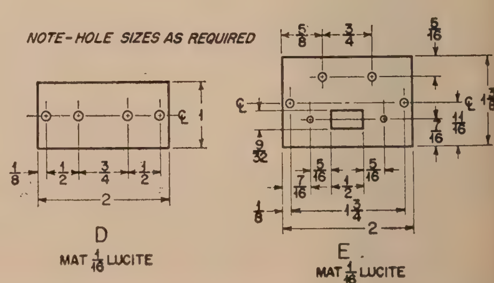
The first step in calibrating the *Antennascope* is to attach an accurate ohmmeter between the "hot" *Rx* terminal and the "hot" r-f generator input terminal. Place the range switch to the left to engage *R1* for the 10 to 100-ohm range. Mark out your scale on the face of the base (the design of which is left to the individual) and divide it into steps of from 2 to 5 ohms.

Now slide the switch to the right to engage the higher range and sub-divide the scale into steps of 25 to 50 ohms. Don't be startled to find that the potentiometers increase their resistances in opposite directions. Remember that *R1*, because of this mechanical layout, must be turned counter-clockwise and *R1a* must be turned in a clockwise direction.

It should now be possible to verify these calibration points through a facsimile of an actual r-f measurement. First couple the r-f input of the *Antennascope* to your grid dipper coil and put a 50-ohm resistor across *Rx*. Use a frequency from the grid dipper of about 20 Mc., and while it is oscillating put the range switch on the "low" scale and see if







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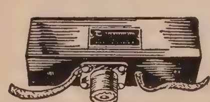

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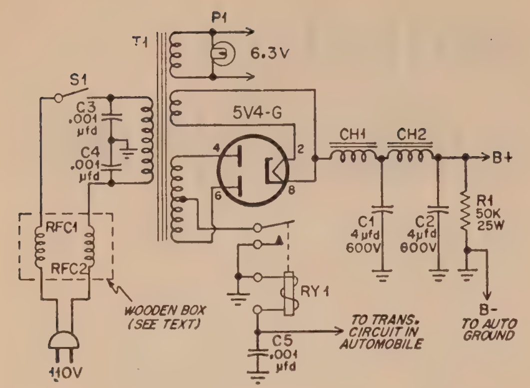


C1,C2—4.0 µfd., 600wv.
C3, C4, C5—0.001 µfd., ceramicon.
Ch1, Ch2—10 henries, 200 ma., UTC S-29.
P1—pilot light assembly, Johnson 147-500.
R1—50,000 ohms, 25 watts.
RFC1, RFC2—1.0 mh., amp., Miller 4534.
Ry1—S.p.d.t. relay, Advance 953B with 6-volt d-c coil.
T1—(300-volt, 150-ma output) use Stancor PC8411. (400-volt, 200-ma output) use UTC S40 or S43.

Fig. 13. Wiring schematic and parts list of the test bench mobile power supply.

the 50-ohm value is being read. Move to the "high" scale and repeat to see if 50 ohms is also being read there. Rotate each control several times to find a scale value, and see if backlash is absent—it should be.

The readings should result in pronounced nulls on the meter. If only partial nulls other than absolute zero are observable, the *Antennascope* is not working properly. Check first with a different value of test resistor since the first one might have been reactive. It is important to keep the leads very short during this test and that the resistor be non-reactive—oddly enough some are quite reactive.

Once a null has been found with a given resistor you will find that lead length can upset the balance. The leads of your test resistor must also be very short. Do not parallel connect resistors for testing the *Antennascope*—use non-reactive ½-watt single resistors.

Poor nulls can result from stray coupling effects in the *Antennascope*, but if the wiring and chassis layout is followed as shown in the figures this trouble should not arise.

Mobile Antenna Measurements

The feed-point impedance of parasitic arrays and low-frequency mobile antennas may be less than ten ohms. Although this low-impedance may be inverted through the use of a ¼-wave line, there is a simpler way of measuring it.

Just connect a non-inductive resistor between the "hot" *Rx* terminal and the load. The measured impedance will be the load impedance, plus the added resistance. For example, if a 50-ohm resistor is used and the *Antennascope* reads 54 ohms, the actual load resistance is four ohms.

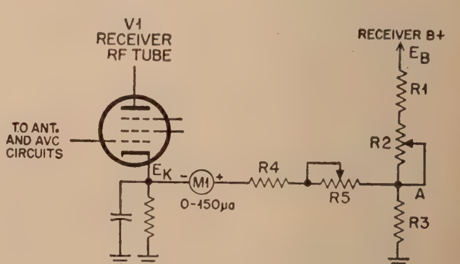
a Mobile Test Power Supply

During testing and tune-up periods it is a great advantage to operate the mobile transmitter from 117 volts a-c, rather than from the 6-volt car battery. The a-c operated power supply described herewith is designed to take the place of the dynamotor or vibrator supply in the automobile during periods when testing is being done. This will have a great amount of wear and tear that would normally be inflicted on the car battery.

Care must be taken to make sure that the a-c operated test supply conforms in output voltage and current capacity to the dynamotor it replaces. The control circuits also must be so arranged that the test supply may be turned on and off by the usual transmitting switches and relays. This may be done by the addition of a 6-volt d-c relay to the supply. This relay, *Ry1*, makes and breaks the center tap of the high voltage supply. It is controlled by the "transmit" circuits in the car.

In addition, the a-c supply must not upset the antenna balance by adding extra capacity between the automobile and the ground. Suitable r-f isolation between the a-c line and the power supply must be provided for correct operation of the equipment.

A supply that meets these requirements is shown in *Fig. 13*. The transformer *T1*, is chosen so as to provide a d-c output voltage of 300 or 400 volts. A two-section filter (*C1, C2, CH1, CH2*) is used to reduce the ripple to a suitable level for phone operation. The d-c out-



R1—150,000 ohm, ½w.
R2—100,000-ohm potentiometer, Centralab B-40.
R3—2000 ohm, ½w.
R4—5000 ohm, ½w.
R5—10,000-ohm potentiometer, Centralab B-14.

Fig. 14. The Basic S-meter circuit.

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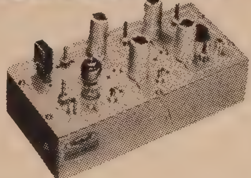
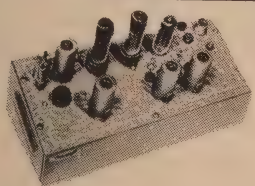
Tecraft CONVERTERS FOR THE NC-300



This is the same high quality crystal converter that has been so enthusiastically accepted by Hams, CAP and CD—those who consider high quality and top performance a must. The IF output frequency range for this converter is either 14-19, 26-31 or 30-35 mc for the new NC-300. Completely detailed literature is available on request.

Model CC5-50	50 mc	(6 meters)	**Net** Any type
Model CC5-144	144 mc	(2 meters)	
Model CC5-220	220 mc	(1.5 meters)	**$42.50**



Tecraft TERRIFIC 10.8 WATT TRANSMITTER

This transmitter employs Hi-level plate modulation, has provisions for metering all stages, a RF output indicator and a tuned antenna output system to 52/72 ohm line. Power: 6.3 vac @ 4 amps, 250 vdc @ 250 ma. Tubes: 6AU6 oscillator, 5763 Multi/amp, 6360 Mult/amp, 6360 final amp, 12AX7 speech amp and driver, 2—6AQ5 Modulators. Pwr. Imp. to final—20 W.

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Model TR 144	144 mc		
Model TR 220	220 mc		**Net $59.95**

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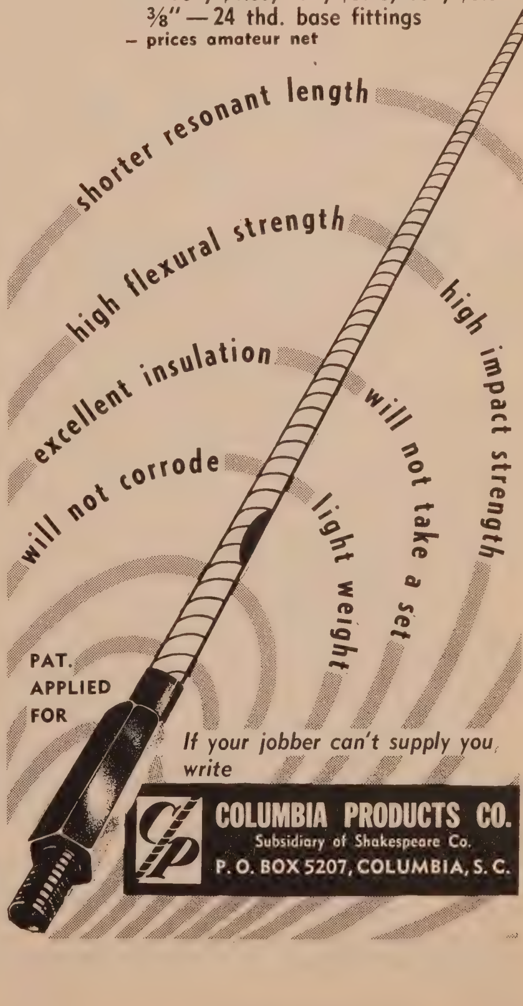

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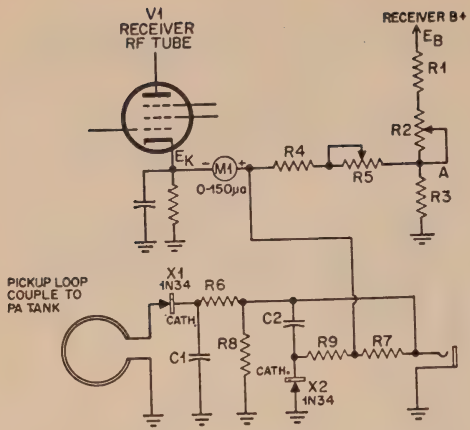

C1—50C μμfd., Erie GP2K-501.
C2—0.05 μfd., 200wv., Sprague 2TM-S5.
J1—open circuit jack.
L1—one turn link near p-a tank coil.
M1—0-150 ua. d-c meter.
R1—150,000 ohm, ½w.
R2—100,000-ohm potentiometer, Centralab B-40.
R3—2000 ohm, ½w.
R4, R8—5000 ohm, ½w.
R5—10,000-ohm potentiometer, Centralab B-14.
R6—1000 ohm, ½w.
R7—82,000 ohm, ½w.
R9—10,000 ohm, ½w.
X1, X2—1N34 crystal diodes.

Fig. 15. Complete S-meter, carrier level and modulation indicator circuit for the "Crystal Ball" designed by W2CVV.

put from the supply is controlled by relay *Ry1*. The high voltage output of the test supply may be connected directly to the transmitter high voltage connector by means of a matching receptacle mounted on the test supply.

The transmitter filaments may either be run from the 6.3-volt winding of the power transformer, or may be left connected to the automobile battery and run from the automobile electrical system. Since the filament drain of a transmitter is small compared to the dynamotor drain, it will not hurt a well-charged battery to run the filaments of the transmitter for short testing periods.

RFC1 and *RFC2* are placed in the 117-volt line to the test supply. These chokes isolate the r-f circuits of the mobile transmitter from the a-c line. They should be mounted in a small wooden box and placed in the line cord a few feet from the supply, so that when the supply is placed in the automobile, the chokes will hang in the air, a few inches below the automobile. They should not be allowed to touch either the car or the ground.

While the cost of such a supply may make it uneconomical for a single mobile installation, it is a very worthwhile club project, where the cost of the supply may be divided among the members of the club.

the "Crystal Ball"

The "Crystal Ball" is a combination S-meter, carrier meter and modulation level indicator. A device such as this that will give an indication of whether or not the transmitter is on the air, if it is modulated and the degree of modulation can be of great value for mobile operation, where the dynamotor whine or a single plate meter may be the only means of monitoring transmissions. In addition, the *Crystal Ball* acts as a forward reading S-meter when the receiver is in operation.

The Basic S-Meter Circuit

A 0-150 microammeter acts as an indicator in a balanced bridge circuit, one leg of which is the plate resistance of an a-v-c controlled tube in the car receiver. The resistance values given with *Fig. 15* are typical, and may need to be varied if the particular receiver in use has a different plate voltage, if the no signal cathode voltage of the a-v-c tube is different, or if a meter of different sensitivity is used. If any one of these parameters is appreciably varied from those specified, the new values of the resistors may be calculated as follows:

1. Measure the a-v-c controlled tube cathode voltage (*Ek*) with no signal input to the receiver.
2. Measure the plate voltage (*Eb*) to which *R1* is connected.

$$R1 + \frac{R2}{2} = Eb \times 1000$$

$$R3 = Ek \times 1000$$

$$R4 + \frac{R5}{2} = \frac{Ek}{Im} \times 1000$$

(*Im* is the full scale current reading of the meter in milliamperes)

The nearest standard resistor values may

The "Crystal Ball" installed on the dashboard within easy view of the operator.

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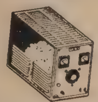

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4-65A	19.49	6J5	.40	832A	5.49
5V4	1.28	6J6	.45	837	1.01
6AG7	1.14	6L6	.90	1625	.44
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be used, and the results will be well within the range of adjustment of *R5*. As a rough check, *R5*, with half its resistance in the circuit should form from one-quarter to one-half of the total resistance of each leg.

3. With *R5* set at mid-scale, and no signal being received, adjust *R2* for zero reading on the meter. This occurs when the voltage at point *A* is the same as at *Ek*.
4. Now tune in an S9 signal. (You will have to decide what an S9 signal is!) Adjust *R5* until the meter reads at the point which you wish to call S9.

The Transmitter Monitoring Circuit

When transmitting the plate voltage is usually removed from the receiver and the S-meter reads zero, and is thus available for other functions. The addition of a pick-up loop, coupled to the transmitter output tank circuit and a crystal rectifier will allow the meter to indicate the relative output power of the transmitter. The complete circuit allowing these two separate functions to operate the meter independently of each other is shown in *Fig. 15*.

The S-meter circuit remains the same. R.f. from the transmitter tank is sampled by the pick-up loop and rectified by *X1*. The output of this portion of the circuit is d.c. varying in amplitude at an audio rate with modulation. *R6* is included to protect the crystal from possible overload and burn-out. It should be mounted near the crystal. A portion of the d-c output of *X1* is fed directly to the meter through *R7*. This will provide about ½ scale deflection of the meter from the carrier only, as an indication of carrier level. The remainder of the d.c. from *X1* is by-passed to ground by *R8*, but the audio components corresponding to modulation are rectified in *X2* and impressed on the meter through *R9*, causing it to swing from its carrier level toward full scale with modulation.

The constants shown in *Fig. 15* are intended to produce approximately ½ scale deflection of the meter from the carrier, provided the coupling loop is so adjusted as to produce five volts of d.c. across *R8*. The meter will swing just about full scale under 100% voice modulation. If it is desired to reduce the modulation sensitivity, increasing the value of *R9* will do it effectively. *R7* may be varied to control the carrier sensitivity.

A jack is included across the output of *X1*. Plugging a pair of earphones in it will permit checking modulation quality.

The pickup loop will have to be adjusted for each transmitter, but to give an idea of where to start, one turn about ½ inch from the "cold" end of the tank coil was found to be correct on both 4 Mc. and 29 Mc. with 40 watts input to the final amplifier.

Make all adjustments with the transmitter fully loaded, since both the tank current and crystal current go up with no-load operation.

Be sure the plate voltage is removed from the a-v-c controlled tube of the receiver and from the balancing network while transmitting, otherwise the S-meter current will be flowing through the meter during transmission monitoring periods.

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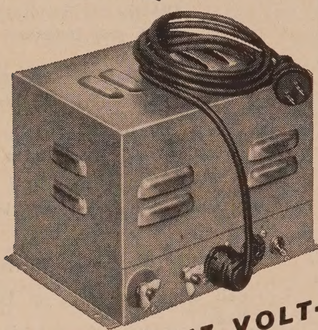

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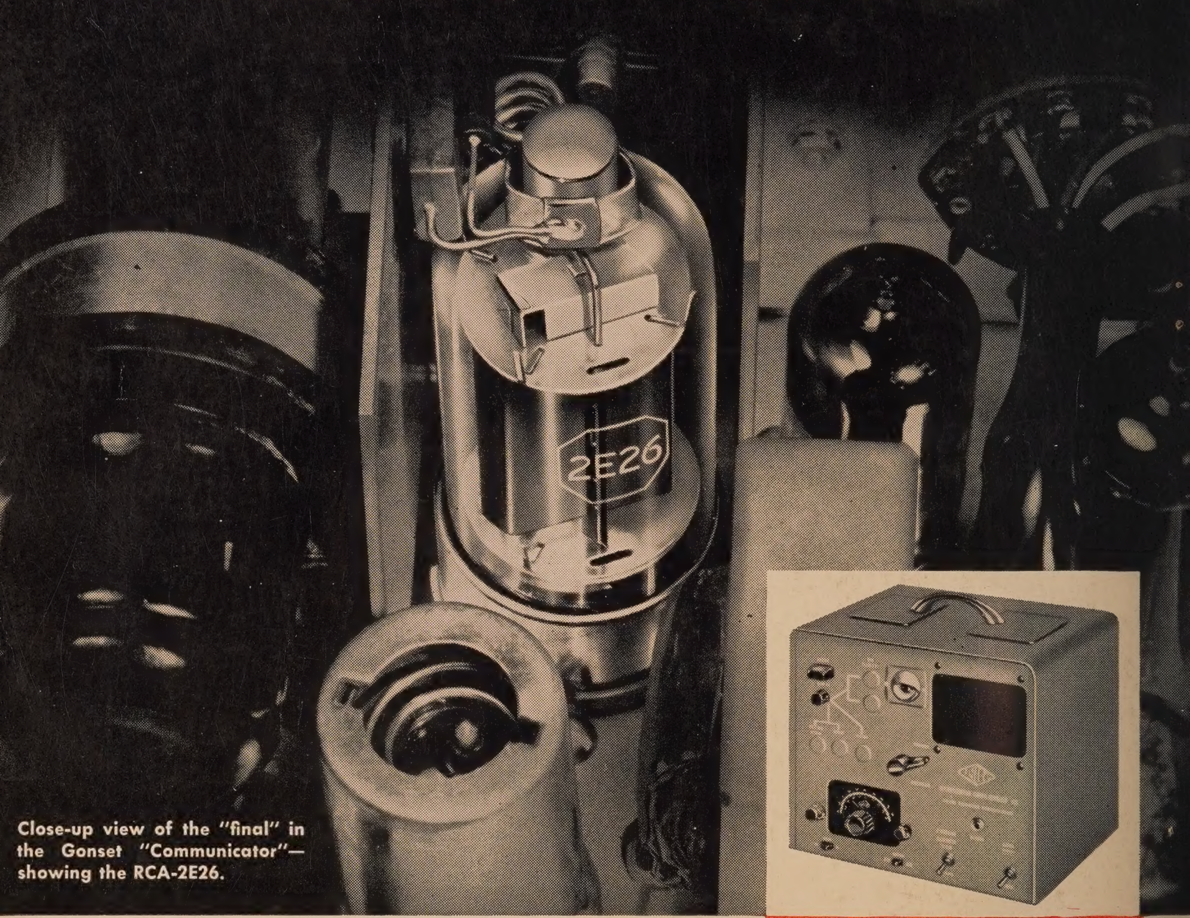

Close-up view of the "final" in the Gonset "Communicator"—showing the RCA-2E26.

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